EDUCATION DEPARTMENT

ONTARIO

MANUAL OF HYGIENE

FOR USE IN

NORMAL AND MODEL SCHOOLS.

Price 50 Cents.

Authorized by the Department of Education.

Gift

Ed. P. A.

MANUAL OF HYGIENE

FOR

SCHOOLS AND COLLEGES.

PREPARED BY THE

PROVINCIAL BOARD OF HEALTH.

Authorized by the Minister of Education for use
in all schools under the control of the
Education Department.

Special Edition

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FOR

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PREFACE.

The want has long been felt of a work on Hygiene, which would occupy an intermediate place between the elementary text-books for the use of children, and the advanced treatises for practitioners of medicine, sanitary engineers, and other persons intending to become experts in Sanitary Science. This book is designed to meet, in some degree, that want. Whilst many of the calculations, and much of the matter, contained in it are expressed in terms not suited to a child, it is, on the other hand, free, as far as may be, from technical expressions not readily understood by the ordinary reader.

Whilst it is primarily intended for teachers, and for pupils in attendance at the Normal and other Schools of the higher grade it is hoped that it may be read with interest and profit by other persons; and that a perusal of it, coupled with an earnest desire to put in practice any good suggestions that may be offered, will be productive of increased health and vigor, and a lessened death-rate. It is intended to present such a knowledge of sanitary matters as every intelligent citizen should possess.

It will be found that the book is mainly devoted to considerations of those matters of Hygiene in regard to which a controlling or modifying influence may be exercised by those for whom it is intended. Such points in Physiology and Anatomy are taken up as will aid in the hygienic considerations referred to: it has been felt that people will be more likely to put in practice suggestions in Hygiene, for which they understand the physiological reasons, than they will mere dogmatic directions.

The chapters have been written by various members of the Provincial Board of Health of Ontario, in such intervals of time as they could find amid their ordinary avocations. They have to thank certain other gentlemen for suggestions in their respective specialties, as well as to acknowledge their indebtedness to the authors of the following works :—

Adulteration of Food Reports, Canada; American Quarterly Journal of the Medical Sciences; Aitken's Practice of Medicine.

Beale on the Microscope; Burdon Sanderson, Works of; Buck's Hygiene; Buck on the Ear; Blyth's Dictionary of Hygiene; Bartholow's Materia Medica.

Carpmael, Reports of the Meteorological Service of the Dominion of Canada; Corfield, Lecture on Parasites (English Health Exhibition Literature); Coulier and Lévy, "Sur l'occupation des Mineurs"; Corradi, Valin and Ziegler, Papers read at the Fourth International Congress, Geneva; Connecticut State Board of Health Reports, (Paper by the late Mr. W. R. Briggs); Carpenter's Physiology of Temperance and Total Abstinence; Cooke, Rev. Joseph, Lectures.

Dalton's Physiology and Hygiene; Denison, Dr. Chas., "Health Resorts of the Rockies"; Dickinson on Albuminuria.

Flint's Physiology; Flint's Practice of Medicine; Foster's Physiology; Fox's Sanitary Examination of Water, Air and Food.

Hodgins, Dr. J. G., School Architecture; Hammond's Hygiene; Holmes's Surgery; Harlan's "Eyesight, and How to Care for it"; Huxley on Technical Education.

Kirke's Manual of Physiology, by Baker and Harris.

Latham's Sanitary Engineering; Lincoln on "Ventilation and Warming," and on "School Hygiene"; Local Government Board Reports, Great Britain.

Massachusetts State Board of Health Reports; Michigan State Board of Health Reports; Maclagan, Germ Theory of Disease; Murchison, Observations on Periods of Incubation, etc.; McSherry's, "Health and How to Promote It."

New York State Board of Health Reports.

Pavy's Food and Dietetics; Parkes' Manual of Practical Hygiene, edited by De Chaumont; Playfair, Sir Lyon, Speech in the House of Commons.

Registrar-General's Reports, England; Registrar-General's Reports, Ontario; Red Cross Society's Publications; Riant's Hygiène Scolaire; Richardson on Alcohol.

Sternberg, Raymond, Smart, Vaughan, Leeds, Watkins and Rohé, "Report of the Committee on Disinfectants of the American Public Health Association"; Spenser, Herbert, on Education; Smith, Rev. James, M.A., Prize Essay, "The Temperance Reformation and its Claims upon the Christian Church."

Taylor's Medical Jurisprudence; The Care of the Teeth, by J. W. White, D.D.S.; Teale, Presidential Address at Huddersfield.

Watson's Practice of Medicine; Waring's Sanitary Drainage; Wilson's Handbook of Hygiene.

Ziemssen's Cyclopedia, Articles by Liebert, Liebermeister and Oertel.

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CHAPTER XXII.

MANUAL OF HYGIENE.

CHAPTER I.

DEFINITIONS AND OBJECTS OF SANITARY SCIENCE — EXAMPLES AND STATISTICS SHOWING THE RESULTS OF IMPROVED SANITARY CONDITIONS—VITAL STATISTICS.

1. Hygiene may be defined as the science which treats of the preservation of life and health by the application of scientific laws to agencies and things in common use.

Great and unnecessary waste of life, health and vigor has resulted, and still results, from a neglect of scientific principles in regard to common things. There are many of these, such as the amount of fresh air and breathing space in our dwelling-rooms, school-rooms and work-rooms, the disposal of the refuse of our households, the position and condition of wells and other sources of water-supply, bathing, clothing and other matters, which appear so trivial, common and simple to people in general, that they do not consider the aggregate importance of slight differences in regard to them; and yet these little every-day matters largely affect life and health.

2. The scope and objects of Hygiene are by many persons confounded with those of the practice of medicine, the feeling being that the study of all matters relating to hygiene may be relegated to professional men. Now, whilst it is unwise to attempt to treat disease without the advice of those who have made a special study of it, it is certainly not unwise to endeavor to understand and practice the ordering of our daily lives and surroundings in such a manner as to avoid sickness and to maintain the highest condition of health. Nor is it wise to await the onset of disease and the arrival of a physician before

remedying unsanitary conditions which may render his best efforts unavailing. In like manner, whilst we may err in neglecting the advice of the architect, the engineer, and the chemist, we should ourselves understand the elementary principles of hygiene as it is connected with their professions; otherwise we shall, to the great detriment of health, overlook even the occasion and necessity of seeking their advice.

3. **Some idea of the importance to us** of carrying correct sanitary principles into practice, may be obtained by considering what has been gained by increased attention to even a few of them in certain instances in which we have reliable statistics to inform us of the results. For example, by adding the columns of population and deaths as given on page 243 of the "Statesman's Year Book" for 1883, we shall find that the average death-rate for the six years prior to the passing of the Public Health Act of 1875 was 22.09 per 1,000, and for the six years following the passage of that Act it was 20.63. The total saving of lives effected in six years was 219,118. In England and Wales alone, there were saved a number more than twice as great as that of the British army for the same period. The figures quoted are from one of the most accurate statistical records in the world; and this great decrease of the death-rate has taken place notwithstanding the fact that as years have rolled on the population has been growing more dense.

4. **The Sanitary Reforms by which this result** was achieved were, in general terms, the cleansing of premises, both private and public, the establishment of correct systems of plumbing and drainage, the improvement of water and food supplies, and greater care regarding the isolation of cases of infectious disease. These reforms were the more strictly and generally carried out through the agency of local boards of health, which by the Act referred to were extended to districts which had hitherto been without them; but they were in the main executed by individuals in their own households.

The distinguished sanitarian, Mr. Edwin Chadwick, stated before the British Association a few years ago that both the sickness-rate and the death-rate of Great Britain had been reduced one-third by the practice of sanitary laws; that in many parts it had been reduced much lower; and that it is his belief, from what has been demon-

strated, that with a more perfect system it may be reduced by two-thirds of its former rate.

5. The number of recorded deaths in Ontario in 1882 was 21,800. Applying, then, Mr. Chadwick's calculations to this Province, we can form some idea of the saving of life that may be effected by a proper knowledge of sanitary laws.

It is needless to say that no money statement can adequately express what this saving of life means. No words of ours are necessary to add to the feelings of any right-minded person regarding its desirability from a humane, social or religious standpoint. Nevertheless, the question has its financial aspect, and statistics in regard to this may be of some value. The money-saving ultimately possible in this Province, as based on the statements of Mr. Chadwick, is computed at $9,540,000 per annum.

6. When a virulent epidemic, such as cholera or small-pox, threatens the community, what alarm and activity are manifested; and yet more deaths are caused yearly by the want of means for securing thorough cleanliness of streets, lanes and premises, good ventilation, effective drainage and ventilation of drains, good water-supply, isolation of infected persons, and careful disinfection, than have ever been superadded to the ordinary mortality by any epidemic of cholera or small-pox that has occurred in modern times.

7. From the Reports of the Registrar-General of Ontario we find that in the year 1881 the recorded deaths from diphtheria were 1,171; from scarlet fever, 470; and from all those diseases which are readily admitted to "spread" from a first case there was a total of over 3,000. The question having been asked of a number of medical men whether they thought one-half of the cases in their neighborhood could have been prevented if proper sanitary precautions had been observed, the answer invariably was that a greater saving than that might have been effected. But let us content ourselves with assuming that one-half might have been prevented; this will give us 1,500 persons who might have been saved from death by contagious diseases. Consider along with this how many of the 2,397 persons who died in that year from pulmonary consumption might still be alive if better ventilation had been adopted. Add to both these, the numbers who might have been saved from death from filth diseases and from accidents pre-

ventable to a certain extent by proper regulations, and to this again add the numbers of sick who did not die, and we think there will be enough to convince the most unprogressive of the urgent necessity for greater attention being paid to sanitary science and sanitary art. From subsequent reports we find a diminution in the number of deaths from these communicable diseases, the totals obtained being 3,033 for 1881, 2,821 for 1882, 2,143 for 1883, and 2,073 for 1884.

8. The records of the army service furnish some striking examples of the diminution of the sickness and mortality rates on account of improved sanitary conditions. Owing to the discipline and uniformity that exist, changes, when ordered, are strictly carried out, and statistics are accurately given, so that statements of the results of altered sanitary conditions in the army may be relied upon.

In India, where the mortality used to be very great, a marked diminution has resulted, as may be seen by the following table taken from De Chaumont's edition of "Parkes' Hygiene":—

MORTALITY OF EUROPEANS PER 1,000.

	Bengal Presidency.	Bombay Presidency.	Madras Presidency.
1845–50. (Chevers)	63.38	60.20	59.20
1838–56. (Queen's troops alone. Balfour)	79.20	61.10	62.90
1806–56. (East India Company's troops alone. Indian Sanitary Commissioners)	74.10	66.00	63.50
1860–69. (Ten years. Balfour)	31-27	22.58	22.53
1870–79. (Ten years. A. M. D. Reports)	20.17	16.37	18.97

The reasons for this diminution are thus stated by Dr. Parkes:—

"After the mutiny, about the year 1860, the sanitary improvements and the greater care of the troops, which had been gradually taking place, received an immense impulse. The results are shown . . [above]."

9. The West Indies also used to be very unhealthy for troops. The names of certain of the stations are familiarly associated, in the minds of some, with painful recitals of death and disease; and this was attributed to "the climate." Of these islands Dr. Parkes thus writes in his work on "Practical Hygiene":—

"The history of sanitary science affords many striking instances of the removal of disease to an extent almost incredible. Formerly service in the

West Indies was looked on as almost certain death. It is little over sixty years since the usual time for the disappearance of a regiment 1,000 strong was five years. Occasionally in a single year a regiment would lose 300 men; and there occurred from time to time epochs of such fatality that it was a common opinion that some wonderful morbid power, returning in cycles of years—some wave of poison—swept over the devoted islands, as sudden, as unlooked for, and as destructive as the hurricanes which so sorely plague the

"'Golden isles set in the silver sea.'

"At present this dreaded service has almost lost its terrors. There still occur local attacks of yellow fever, which may cause a great mortality; but for these local causes can be found, and otherwise the stations in the West Indies can now show a degree of salubrity almost equalling, in some cases surpassing, that of the home service."

10. The causes of the production, and the reasons of the cessation, of this great mortality are described at great length, and the latter are then summarized as follows:—

"Among the measures which have wrought such marvels in the West Indies have been—1st. A better supply of food; good, fresh meat is now issued, and vegetables, of which there is an abundance everywhere. 2nd. Better water. 3rd. More room in barracks, though the amount of cubic space is still small. 4th. Removal of some of the stations from the plains to the hills. . . . . 5th. Better sewage arrangements, and more attention generally to sanitary conservancy. 6th. A more regular and temperate life, both in eating and drinking, on the part of both officers and men. 7th. Occupancy of the unhealthy places, when retained as stations, by black troops. 8th. Better . . . [and] . . . more suitable dress."

In his detailed description Dr. Parkes traverses many avenues in the domain of hygiene, showing the ill-effects caused by a violation of its principles, and the beneficial results of sanitary reforms.

11. That these same violations occur amongst ourselves, sometimes in less degree, sometimes, unfortunately, not so, will be seen in the following chapters. We have in our dwelling-houses, our schools and our factories instances of over-crowding and want of ventilation as bad as those to which Dr. Parkes alludes. Our modes of disposal of refuse are in most places quite as imperfect and revolting, and act in the same way in producing the typhoid fever that is so prevalent. That we are not scourged to the same extent, as the result of our uncleanliness in this respect, is due to the fact that yellow fever does not live so far north.

Many cases of Typhoid Fever are, however, found throughout this Province at the present time in places where, ten, fifteen or twenty years ago, no cases had occurred. The sickness and mortality from it are more wide-spread than they used to be. To the relations between our methods of sewage-disposal and the surrounding air and water-supply we must look for the explanation.

The errors in diet—intemperance in eating, and the eating of improper foods—described by Dr. Parkes, are not without parallel in our country; and strong drink is responsible here, too, for a very large number of deaths. To these causes of sickness and mortality may be added those arising from improper dress, excessive brain-work, injudicious exercise on the one hand and insufficient exercise on the other, want of knowledge in regard to bathing and the proper care and exercise of the excretory organs, want of care of the eye-sight and hearing, and unnecessary exposure of the body in general to accidents and contagious diseases. These points will be considered in the following chapters.

12. The reduction of Typhoid Fever by improved sewerage and water-supply has been well illustrated practically in the histories of certain cities, statistics regarding which were given in an address by Capt. Douglas Galton before the Sanitary Institute of Great Britain at its fifth annual meeting. From his remarks and the Reports of the Registrar-General of Ontario we have compiled the table which will be found on the opposite page. It will be seen that the records of deaths from typhoid fever in the three largest cities of this Province for the past few years correspond very closely with those of the European cities during the earlier periods given in the table. The sanitary conditions are also very similar. We think we may add that in some respects the dawn of improvement has commenced in our cities. It is to be hoped that at no distant day the faulty systems of sewage disposal will be remedied, and that the parallel may be carried out as regards the improved sanitary condition and the diminution of the death-rate. Boards of health have recently been organized on a fresh basis, and in the two larger cities medical health officers have been appointed. The city water-works are being extended in all these cities, and wells are thus being gradually superseded. The health officers are trying by degrees to abolish privy pits. Efforts are being

made to have skilled inspection of plumbing and house drainage; and in Hamilton a crematory has been erected for burning refuse.

City.	Period.	Sanitary Condition.	Death-rate per 100,000 from Typhoid Fever.	Period.	Changes in Sanitary Condition.	Death-rate per 100,000 from Typhoid Fever.
Frankfort-on-the-Main.	1854–59	No sewerage..	87	1875–80	Sewerage completed.	24
Dantzic.......	1865–69	No sewerage; no proper water-supply.	108	1871–75	Water-supply introduced.	90
				1878–80	Sewerage added.	18
Munich.......	1854–59	Absolutely no regulations for keeping the soil clean.	242	1860–65	Reforms begun by cementing the sides and bottoms of cess-pits.	168
				1866–73	Partial sewerage.	133
				1876–80	Sewerage improved.	87
				1881–84	Sewerage still further improved.	17
Toronto	1881 1882 1883 1884	Partial sewerage and water supply in these cities, but sewage not carried to a safe distance nor properly disposed of; many privy pits polluting the soil and wells; refuse deposited in ravines and hollows; no skilled inspection of house drainage.	74 69 80 65			
Hamilton ...	1881 1882 1883 1884		65 47 30 41			
London.....	1882 1883 1884		110 52 65			

13. Statistics of cities which are remarkable examples of the results of sanitary improvements in reducing the total death-rate are also given by various authorities. In Newcastle, according to Capt. Galton, the death-rate has been reduced by such improvements from 27.6 per 1,000 in the quinquennial period beginning in 1868 to 23 in the quinquennial period ending in 1881, whilst in 1881 it was only 21.7. In Birmingham there has been a remarkable reduction in the number of deaths from diphtheria and typhoid fever. In one of the English blue books we find a record of the diminution of the death-rates of twelve of the smaller towns in which improved systems of sewerage and water-supply had been established, which is well worthy of being reproduced, and which should claim our attentive consideration:—

PLACE.	Average mortality per 1,000 before construction of works.	Average mortality per 1,000 since completion of works.	Saving of Life per cent.	Reduction of Typhoid Fever. Rate per cent.	Reduction in Rate of Phthisis, per cent.
Banbury	23.4	20.5	12½	48	41
Cardiff	33.2	22.6	32	40	17
Croyden............	23.7	18.6	22	63	17
Dover	22.6	20.9	7	36	20
Ely	23.9	20.5	14	56	47
Leicester	26.4	25.2	4½	48	32
Macclesfield	29.8	23.7	20	48	31
Merthyr............	33.2	26.2	18	60	11
Newport	31.8	21.6	32	36	32
Rugby	19.1	18.6	2½	10	43
Salisbury	27.5	21.9	20	75	49
Warwick	22.7	21.0	7½	52	19

14. The Vital Statistics of our own Province furnish us with many facts of great importance in a hygienic point of view. A study of these would prove very interesting, but we will only have space to take up in this connection one line of investigation in addition to the references to our statistics which have already been made. The tables of "Deaths by Occupations," in the Reports of the Registrar-General of Ontario for 1882 and 1883, inform us of the average ages at death of persons who were engaged in various employments. Some of these figures are well worthy of note as showing the results of unsanitary

conditions co-existing with certain occupations, most of which conditions are capable of being remedied. We give a few examples :—

	Average Age at Death in 1882.	Average Age at Death in 1883.
Printers	32.31	32.5
Seamstresses	32.70	42.2
Milliners and Dressmakers	36.81	43.5
Chemists and Druggists	36.84	49.7
Barbers	37.86	41.3
Railway Employees	38.86	38.5

Mark the short average duration of life as compared with the following :—

	Average Age at Death in 1882.	Average Age at Death in 1883.
Gardeners	64.5	62.8
Hunters and Fishermen	62 8	50
Farmers	61.4	62.2
Clergymen	60.5	56
Farmers' Wives	58.8	59.7
Contractors and Builders	56 4	54.5

15. **The special causes of the vitiation of the air** of printing offices will be referred to in a future chapter. The results of close indoor employment in air rendered impure from various causes are sharply contrasted, in the first five employments mentioned, with those of the outdoor life of gardeners, farmers and builders, and the more varied life of the clergyman; whilst the statistics indicating the term of life which falls to the lot of her who sits,

> "With fingers weary and worn . . .
> Plying her needle and thread,"

do not belie the popular belief regarding the life of the seamstress. The relative longevity of the stonecutter, inhaling the dust which he throws into the air, (47.63 years,) and of the stonemason, (64.30,) are very different, though both live out of doors during a great deal of their time. The above figures do not differ materially from those given in a "Review of the Deaths of the Last Decennial Period."

16. **Statistics which might mislead us** regarding certain occupations have been purposely omitted in our illustrations. For instance, the average age of female teachers, calculated from the deaths for 1882,

would be a little over 36 years, and that of male teachers nearly 75. Whilst there are influences which cause a greater deterioration of health among female than among male teachers, we can hardly suppose that the difference is so great as these figures might seem to indicate. Is it not a probable explanation of the excessive disparity that after marriage females more commonly give up the vocation of teaching than do males, hence there are fewer female teachers to die old? On the other hand, we may point out that this does not at all detract from the force of the remarks in a subsequent chapter regarding the ventilation of school-rooms; for whilst the total deaths of all persons between 30 and 40 is 1359, and the total deaths from phthisis at that age 440—a proportion of 1 to 3.08—the proportion worked out for female teachers (for whom the average age is given as 36) is 1 to 2.25; or, taking another comparison, whilst the age at death of female teachers is the same as that of female servants, the death-rate from phthisis of the former is 1 in 2.25 and of the latter 1 in 6.5. In other words, whilst the total death-rate of female teachers may not be unfavorable as compared with that of some other classes, the deaths from phthisis amongst the former is out of all proportion; it is even greater than that of printers and stonecutters (of all ages, however).

CHAPTER II.

THE BLOOD—COMPOSITION, USES, CIRCULATION, AND AERATION OF.

17. The Blood is an animal fluid, formed chiefly from the chyle, and acquiring important properties during respiration. It enters every organ through the circulation, distributes the nutritive principles to every tissue, and is the source of every secretion. Human blood, flowing from the body, is a thickish, heavy fluid, of bright scarlet color when it comes from an artery, deep purple or nearly black when it flows from a vein. Its specific gravity at 60° Fahr. is on an average 1055. Its temperature in health is generally 100° Fahr., and it has a slight alkaline reaction. Blood taken from the body and left to itself in a vessel separates into two distinct parts—the *serum*, or watery, supernatant fluid, and the *coagulum*, or clot.

18. Chemical analysis shows the average proportions of the principal constituents of the blood in 1,000 parts to be—

Water	784.
Red blood cells	131.
Albumen of serum	70.
Saline matters	6.03
Extractive, fatty and other matters	6.77
Fibrine	2.2
	1,000

19. Blood-cells are of two principal forms, the red and the white, of which the latter are in process of being developed into the former; and this mode of development continues throughout life. Every new white blood-cell forms itself in and from the materials of the lymph and chyle, and is perfected in the blood; and the blood is maintained by constant repetitions of this process. The human red blood-cells are discs of different sizes, appearing under the microscope like tiny rolls of coin. They are composed of a membraneous cell wall which encloses a peculiar substance impregnated with the red coloring matter

or hæmatine. Hæmatine contains 6.64 per cent. of iron, in the form, most probably, of the simple element. It is distinguished from all other animal bodies by its blood-red color. This peculiar color does not, however, depend on the iron; for hæmatine may retain its color after all the iron has been extracted from it. Therefore the changes produced in the color of the blood by respiration, to which allusion will be made further on, cannot be ascribed to any changes in the condition of the iron in the hæmatine. They are probably due to the fact that the oxygen, by first contracting the blood cells and thickening their walls, makes them so reflect light as to appear, in mass, bright red; and carbon dioxide, on the contrary, by dilating them and thinning their walls, makes them reflect less light, and appear, in mass, nearly black.

20. Fibrine appears to be developed commensurately with the blood-cells, and in like manner is perfected in the blood. The coagulation or clotting of the blood is due to the organization of its fibrine, and indicates a capacity for developing and acquiring higher organization in conditions favorable to life.

21. Of the inorganic constituents of the blood—the substances which remain as ashes after its complete burning—one may observe in general that they are small in quantity in proportion to the animal matter contained in it. Those among them of peculiar interest are the phosphate and carbonate of soda and the phosphate of lime. In illustration of the characters which the blood may derive from the phosphate of soda, Liebig points out the large capacity which solutions of that salt have of absorbing carbon dioxide, and giving it off again when agitated in atmospheric air and when the atmospheric pressure is diminished.

22. The fatty matters which are found in the tissues or secretions exist, for the most part, ready formed in the blood; for it contains the cholesterine of the bile, the cerebrine and phosphorized fat of the brain, and the margaric and oleic acids of common fat. The quantity of the fatty matters in the blood varies, being commonly increased after each meal in which fat, starch or saccharine substances have been taken.

23. The water of the Blood varies from hour to hour in its quantity, according to the period which has elapsed since the taking of food or

drink, the amount of bodily exercise, the state of the atmosphere, and all the other events that may affect the ingestion or excretion of fluids. According to these conditions it may vary from 70 to 79 per cent. Uniformity is, however, maintained, because whatever tends to lower the proportion of water in the blood, such as active exercise or the addition of saline or other solid matter, excites thirst; whilst, on the other hand, the addition of an excess of water to the blood is quickly followed by its more copious excretion in sweat and urine.

24. The resemblance of flesh and blood, so far as their chemical composition is concerned, is so great that the blood has been aptly termed "flowing flesh," and the results of the ultimate analysis of the blood and of the flesh of the ox so resemble each other that the elementary composition of their organic constituents may be considered identical, and may be represented for both as carbon 45, hydrogen 39, nitrogen 6, and oxygen 15.

25. The purpose of the Blood appears to be threefold. First, to provide materials suitable for the nutrition and maintenance of all the parts of the body; second, to convey oxygen to the several parts, whether for the discharge of their functions or for combination with their refuse; third, to bring from the same parts this refuse and convey it to where it may be discharged. The first is the primary purpose of the blood, but the second and third are essential to life, and will be more especially considered hereafter.

26. The circulation is the means by which these various purposes are accomplished, because it is necessary that the blood should be constantly moving through all the parts, and, at certain periods, should be exposed to the atmosphere, in order that it may absorb oxygen and emit carbon dioxide, water and other waste matters. To this end it is provided in man and all warm-blooded animals, that all the blood, which has passed once through the several parts of the body, shall traverse the lungs and be exposed to the atmosphere before it again takes the same course. The course through which the blood moves, in order to accomplish this object, may be thus described.

27. The general circulation (Fig. 1) commences at the *left ventricle of the heart* (*lv*), blood being impelled into the *aorta* (*ao*) and along its successive branches, the *systemic arteries* (*a*, *a*, *a*, *a*), through which all the organs of the body, except the finer textures of the lungs, derive

all their blood. Through these arteries it is conveyed into the *systemic capillaries* (Figs. 2 and 3), the minute vessels which lie intermediately

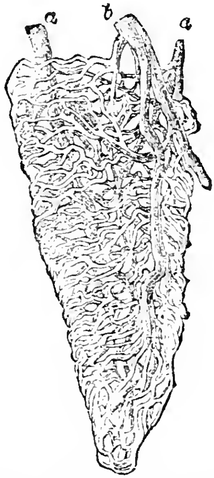


Fig. 2.—Circulation in an intestinal villus, showing the capillaries between (*aa*) the minute branches of the arteries and (*b*) the vein.

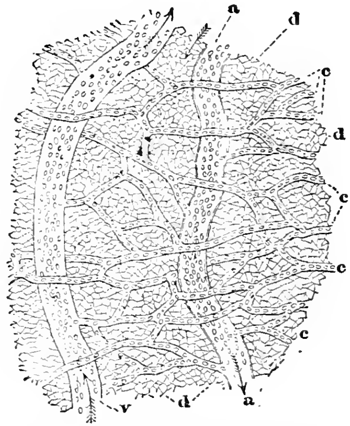


Fig. 3.—Microscopic view of the circulation in the web of a frog's foot: the blood corpuscles traversing (*aa*) an artery, (*cc*) capillaries and (*vv*) a vein; (*dd*), connective tissue.

between the arteries and veins of every part, and in which the blood is brought most nearly into contact with the very substance of the organs. From these it passes into the *systemic veins*, (Fig. 1, *v*, *v*, *v*, *vc*), through the main trunks of which the *venæ cavæ* (*vc*), it flows into the *right auricle* (*ra*), and thence into the *right ventricle* (*rv*), of the heart. This completes the *systemic circulation*, or general part of the circulation.

28. The lesser, or pulmonary circulation, begins at the *right ventricle* (*rv*). The blood passing through the *pulmonary artery* (*pa*) and its branches, in the lungs, expands in the *pulmonary capillaries*, in which it is brought into close proximity to the atmosphere. From the pulmonary capillaries it passes, in converging streams, through the *pulmonary veins* (*pv*) to the *left auricle* (*la*), whence, having traversed the pulmonary circulation, it passes into the *left ventricle*, where, in the case here supposed, it began its course.

29. The color of the blood in the left ventricle is bright scarlet, being arterial, and charged with oxygen in greater proportion than carbon dioxide, as well as with the nutritive materials before referred to. So it remains in all the systemic arteries; but in the systemic capillaries it parts with portions of those materials, and its oxygen is largely consumed in uniting with the hydro-carbons and other substances, which enter the blood-vessels as refuse from the various tissues. Thus the blood acquires a dark venous character, and in this condition it passes through the systemic veins, the right side of the heart and the pulmonary artery. In the pulmonary capillaries, however, emitting carbon dioxide, water and organic matter, and taking up oxygen, it becomes again arterial, and so passes on to the left ventricle.

30. The principal force used in producing this constant movement of the blood is that of the muscular substance of the heart. Other assistant forces are those of the elastic walls of the arteries, the pressure of the muscles, among which some of the veins run, the movements of the walls of the chest in respiration, and perhaps, to some extent, the interchange of relations which takes place between the blood and the tissues in the capillary system.

The average time in which the blood completes its entire circuit in man, is less than one minute.

31. The right direction of the blood's current is maintained by valves, placed between each auricle and ventricle of the heart, at the orifices of communication betwen the ventricles and the main arteries, and in most of the veins. These valves open to permit the movement of the blood in the course just described; but close when any force tends to move it in the opposite direction.

32. Respiration is closely allied with the process we have just described. It has been already stated that one principal object of the circulation is to collect the various impurities, derived from tissue waste, and in part also from the elements of unassimilated food. These impurities are removed by means of *excretory* organs. One of the most abundant of these impurities is carbon dioxide, the removal of which and the introduction of fresh quantities of oxygen, constitute the chief purposes of respiration. Respiration in man and in all mammals is carried on in the minute cavities in the lungs called air-cells.

33. The structure of the lung may be thus described. Each *lobule* or small subdivision of the lung (Fig. 4) consists of a collection of such air-cells, clustered upon and opening into minute branches of the bronchial tubes, and having their walls overlaid with capillaries, derived from the terminal branches of the pulmonary artery. The bronchial tube belonging to each lung passes into its substance, dividing and subdividing, and sending branches to every part of the organ. (Fig. 5.)

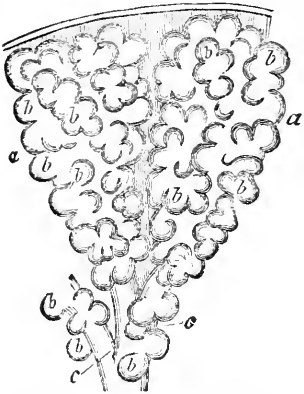


Fig. 4.—*aa*, Two small groups of air-cells; *cc*, ultimate branches of bronchial tubes, communicating with *bb*, air-cells.

34. The larger bronchi have walls formed of tough membrane, with organic-muscular, circular fibres, giving them a power of spontaneous contraction; portions of cartilaginous rings, by which they are kept open; and longitudinal bundles of elastic tissue, for greater power of recoil after extension. They are lined with mucous membrane, the surface of which, like that of the trachea, is covered with vibratile ciliary epithelium. (Fig. 6.)

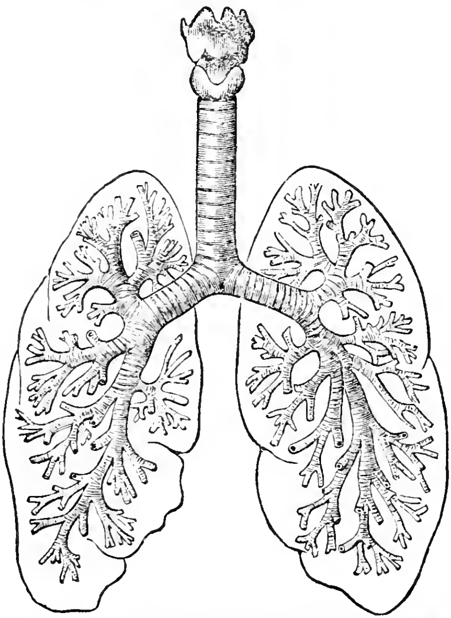


Fig. 5.—Outline of the lungs, with the larynx, trachea and bronchial tubes.

35. The smaller bronchi are not provided with the structures above referred

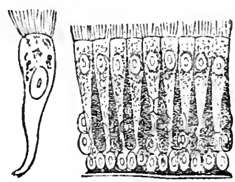


Fig. 6.—Section of the mucous lining of a bronchial tube, showing the cilia on the surface of the epithelial cells. To the left is a cell more highly magnified.

to. They are formed of a tough, elastic membrane with traces of fibrous structure, over which the capillaries are spread in a very dense network, and on various parts of which air-cells open. These tubes have been called inter-cellular passages. The air-cells opening into them may be placed like recesses on their walls; but more often they are arranged in rows like minuter sacculated tubes, so that a series of cells, all opening into one another, open by a common orifice into the bronchial tube. The air-cells are of various forms, their walls are nearly in contact, and they vary from $\frac{1}{120}$ to $\frac{1}{1200}$ of an inch in diameter.

36. The pulmonary capillaries form a network of vessels outside these air-cells, so very close in its nature that the interspaces are narrower than the vessels themselves. Between the air in the air-cells and the blood in the capillaries, nothing intervenes but the thin walls of the air-cells and capillaries and the delicate epithelial lining of the former.

The exposure of the blood to the air is therefore complete, because the folds of membrane between contiguous cells, and often the spaces between the walls of the same, contain only a single layer of capillaries, both sides of which are thus at once exposed to the air.

37. The movements of respiration are two-fold. The movement for taking fresh air into the lungs is called *inspiration*, and that for expelling the air which has been changed by the respiratory process, *expiration*. Inspiration is performed principally by the action of certain muscles, attached to the exterior of the chest (*p*, *sm*, Fig. 81); expiration by the recoil of the lungs and the walls of the chest after they have been dilated, aided by muscular action also.

38. In structure the chest is a cavity closed on every side from the entrance of the air; its immediate boundary is formed by its lining membrane, the pleura; its walls external to the pleura, are partly bony and unyielding, though movable, partly muscular, and partly elastic. It is filled by the lungs, heart and larger vessels, and these fill it equally in all its alterations of size; when it enlarges they receive more air and blood; when it contracts air and blood pass out of them; and the lungs and part of the heart are always in contact with every part of its internal surface. Air fills all the air tubes and cells of the lungs; and through their medium the pressure of the atmosphere is communicated, through the windpipe, to the whole of

the interior of the cavity of the chest, and balances the pressure of the atmosphere on the exterior of the chest. The force, therefore, which is required for the expansion of the chest in inspiration is not more than is necessary for moving the weight of its walls and those of the abdomen, and overcoming their elasticity and that of the lungs.

39. The mechanism of respiration is effected in the following manner:—When the walls of the chest are raised, so as to expand the chest, the pressure on the exterior of the lungs is somewhat less than that of the air on their interior; the excess of pressure, therefore, impels more air into them through the windpipe. On the other hand, when the walls of the chest contract, the pressure is greater on the exterior than on the interior of the lungs, and air is forced out of them through the windpipe, the action being aided, as before stated, by the elasticity of the lungs.

40. The amount of air used in respiration may be calculated from the following data: The quantity of air that is changed in the lungs, in each act of ordinary tranquil breathing, in the case of healthy, young and middle-aged men, is from twenty to twenty-five cubic inches. The number of respirations in a healthy adult person usually ranges from fourteen to eighteen per minute.

41. By the law of the diffusion of gases the carbon dioxide evolved in the air-cells will, independent of any respiratory movement, tend to leave the lungs, by diffusing itself into the external air, where it exists in less proportion; and by the same law, the oxygen of the air will tend to enter the air-cells, in which its proportion is less than in the bronchial tubes, or external to the body.

This interchange of gases is also assisted by the difference in temperature between the air within and that outside of the lungs, and also by the mechanical action of the waving cilia on the mucous membrane of the bronchi. (Fig. 6.)

42. The changes produced in the blood by respiration are considerable. The most obvious is that of color, the dark purple of venous blood being exchanged for the bright scarlet of arterial blood. The essential alterations are, that arterial blood is one or two degrees warmer than venous; that it coagulates sooner and more firmly, apparently containing more fibrine, and that it contains more oxygen and less carbon dioxide and nitrogen. The quantity of oxygen contained

in arterial blood is twice as great as that in venous blood, being equal to from 10 to 10½ per cent. of the volume of the former, and only about 5 per cent. of the volume of the latter. The quantity of carbon dioxide, on the other hand, is less in arterial than in venous blood, amounting to about 20 volumes per cent. in the former, and 25 per cent. in the latter. The quantity of nitrogen contained in the blood varies from about 1.7 to 3.3 per cent. From the fact that it is exhaled, in small quantity, from the lungs, it is thought to be present in greater proportion in venous blood.

43. The mode in which oxygen is contained in the blood may be thus described. After it has been absorbed into the blood from the air in the lungs, part of it mixes with the blood and part is loosely combined with the blood cells. In this condition it reaches the systemic capillaries, where, co-operating in the process of nutrition and the elimination of waste material, one-half of it disappears. A proportionate quantity of carbon dioxide and water is formed, which, being carried to the lungs, is there exhaled, and a fresh supply of oxygen taken in.

CHAPTER III.

THE COMPOSITION OF AIR—ITS IMPURITIES AND THEIR EFFECTS.

44. The air we breathe has in its natural state a nearly uniform composition. It contains two essential elements, oxygen and nitrogen, and two accessory elements, carbon dioxide and water. The association of oxygen and nitrogen in the composition of air is not a chemical union, but a simple mechanical mixture. Oxygen is the absolutely essential element for the support of animal life. Nitrogen seems to act in the animal economy as a vehicle for the administration of oxygen. Carbon dioxide is far from being such an indifferent agent; it is essential, but not to the animal kingdom. To man it is simply a superfluous ingredient, harmless when in moderate amount; to the vegetable world, on the contrary, it is a food, which, together with water, often constitutes the entire life of a plant. Hence, as related to life in its broadest sense, the air may be said to be composed of oxygen, nitrogen and carbon dioxide. Water in a gaseous form is contained in the air, adding little to its bulk. Its value will be made the subject of further remark. Ozone, peroxide of hydrogen, nitrous and nitric acids are occasional components of the air. The three first named are the great purifying agents contained in the air; the first-named being nearly always present in greater or less quantity, the two latter being special productions of the great cleansing operations of nature, such as the precipitation of the rain, storms, hail, dew, falls of snow, etc. Very minute traces of ammonia, mineral matters (such as salts of sodium), and organic matter are also occasionally found in the air.

45. The composition of air varies. A very pure air contains in 100 parts by measure:—

Nitrogen	78.98
Oxygen	20.99
Carbon dioxide	0.03
	100.00

The mean of outdoor air as taken from various specimens, some very pure and some not so good, is given by the late Dr. Angus Smith, as:—

Nitrogen	79.00
Oxygen	20.96
Carbon dioxide	0.04
	100.00

46. Oxygen gas is the life-supporting constituent of air. Roughly speaking, the air, if pure, should contain 20.99 per cent. of oxygen; an average air, out of doors, 20.96. Very bad air begins at 20.6. (Smith.) The following extracts from a table by Dr. A. Smith, show the deviation from a state of purity of air, as respects its life-supporting constituent, oxygen gas, in different situations and under different circumstances:—

	Oxygen—per centage in volume.
Scotland (north-east sea-shore, open heath)	20.99
Manchester, in city (fog and frost)	20.91
London, open parts, summer	20.95
Theatre (pit), 11.30 p.m.	20.74
Backs of houses and closets	20.70
Court of Queen's Bench (1866)	20.65
Mines, under shaft (average of many)	20.42
When candles go out	18.50
Very difficult to remain in for many minutes	17.20
Before the door of a house in Manchester	20.96
In a sitting room, not very close	20.89
In a very small room with a petroleum lamp burning, a good deal of draught	20.84
Do. after six hours	20.83

Similar averages have been obtained by chemists in other parts of the world.

47. Ozone is simply oxygen, which has assumed a new set of properties in consequence of the action of electricity or some other force, its elementary composition remaining the same. It is a very powerful oxidizing agent. This property gives it great value as a disinfectant.

48. The quantity of carbon dioxide is the same in different samples of pure air, as appears evident from the analyses, made by different chemists by dissimilar processes, of air taken under similar conditions in various parts of the world.

	Per cent.
Mean of 18 analyses on Lake Geneva, by Saussure....	.0439
Air of Madrid outside the walls—	
Mean of 12 analyses by Luna	.045
Air of Madrid inside the walls—	
Mean of 12 analyses by Luna	.051
Air of Munich, by Pettenkofer	.050
In the streets of London (summer)	.0380

49. Different kinds of impurities are added to the air, viz.:—by

(1) Respiration and transpiration.

(2) Combustion.

(3) Putrefactive processes, sewage emanations and excremental filth.

(4) Gases, vapors and suspended metallic, mineral and vegetable matters given off by trades and manufactories.

(5) Poisons of unknown nature evolved by damp and filthy soil.

50. The impurities in air exhaled from the lungs are roughly the following:—

(1) 100 parts of such air contain 13, instead of 21, parts of oxygen, the missing 8 parts having been withdrawn by the blood-cells in the lungs.

(2) The .03 or .04 part per cent. of carbon dioxide is increased to between 4 and 5 per cent.

(3) An increase of watery vapor is noted, which is loaded with organic matter.

51. The animal organic matter which is here referred to is probably the most injurious ingredient of re-breathed air. It is also thrown off from the skin by perspiration. It has a very fetid smell, and this is retained for a long time in rooms, even where free ventilation is used.

Substances which imbibe water freely, such as wool, feathers and moist paper, absorb it readily; whilst, on the contrary, substances of an opposite nature, such as straw and horse-hair, take it up to a very slight extent. It is probably not a gas, but is molecular, and floats in clouds through the air, as the odor is not equally diffused through a room. The wood of gymnastic apparatus, and even of school-rooms, if not washed well, has a smell of perspiration, which is highly characteristic. The peculiar sickening odor of animal organic matter is especially noticed in crowds of "the great unwashed," and creates

often in those unaccustomed to such smells a feeling of positive debility. The quantity of organic matter found in air is a measure of its impurity. The discomfort which we experience in badly ventilated rooms, and which was formerly considered to be occasioned by the production of carbon dioxide, we now know to be caused mainly by organic matter.

52. **The amount of carbon dioxide,** is however, as a rule, a measure of other accompanying impurities in the air, and as the amount present in a given sample of air can be easily and yet accurately obtained, even by unskilled observers, it deserves a considerable share of our attention. This gas is produced by respiration and perspiration.

53. **Combustion from fires and lights,** and the decomposition of animal and vegetable refuse also produce immense quantities. Dr. Angus Smith estimated that 15,066 tons of carbon dioxide are daily passed by the city of Manchester into the air; and Dr. De Chaumont states that 822,000,000 cubic feet of this gas are generated in London per diem, or more than 9,500 cubic feet per second. In consequence, however, of its powers of oxidation, and of the physical changes to which it is unceasingly subjected through the agency of storms, rain, currents, temperature, etc., the atmosphere preserves a uniformity of composition which is really marvellous.

54. **Carbon monoxide,** which is a most poisonous gas, is a product of combustion, and is found in the air of towns, where it is so diluted that it does but little injury. In this country, where most buildings, public and private, are warmed by stoves or furnaces in which anthracite coal is burned, especial care should be taken to prevent poisoning by this gas. As it always indicates imperfect combustion, it may be prevented issuing from stoves by seeing that the draught is sufficient, and that the fire burns brightly. It may be seen burning on the surface of a coal fire with a pale, bluish flame. It is generally believed to be a most virulent poison. In a case of poisoning by this gas, transfusion of blood, or the introduction of a saline solution into a vein may become necessary, as the gas becomes so incorporated with the red blood-cells that they are unable to exercise their proper function of carrying oxygen to the tissues. Most people, especially those of nervous or sanguine temperament, those, in fact, who are sensitive to changes in atmospheric states, are injuriously affected if they remain

for some time in a room warmed by a stove or furnace which permits carbon monoxide to escape into the air. They feel a languor and oppression, difficulty of breathing, slight dizziness, confusion of thought, headache, accompanied by a feeling as if a tight band encircled the forehead and temples—in one word, the symptoms of narcotic poisoning.

55. Putrefactive processes are accompanied by the production of gases and vapors, with which are associated organic matter and a septic ferment. Warmth and moisture favor, and cold and dryness retard, these putrid decompositions. In the opinion of Mr. Simon, "the 'septic' ferment, the product of putrefaction, which in its strongest action quickly destroys life by blood poisoning, can, in slighter actions, start in the body slowly advancing processes, which will end in general tubercular or consumptive disease."

56. Sewage emanations are somewhat variable in composition. Most analysts agree in noting a diminution of oxygen and an increase of carbon dioxide, with small proportions of hydrogen sulphide and ammonium sulphide. Sewage effluvia are well known to be injurious to the health of animal and vegetable life, even when mixed with the air in small quantities. The only forms of life that thrive in air thus polluted are certain of the bacteria and fungi, and other of the scavenging families of creation.

The air is also fouled by excremental filth, generally dried and wafted about as dust. The best methods for removing the dangers to health, arising from sewage emanations, will be explained in the chapter on the "Disposal of Refuse."

57. Poisonous gases and vapors, such as muriatic acid vapor from alkali and steel works, arsenical vapors from copper smelting works, hydrofluoric acid from superphosphate manufactories, etc., injure animal and vegetable life, sometimes destroying all trace of the latter for miles around. Then the air is vitiated by bisulphide of carbon from india-rubber works, sulphurous and sulphuric acids from bleaching works and coal combustion, hydrogen sulphide from chemical works where ammonia is manufactured. It is poisoned also by carbon monoxide, carbon dioxide and hydrogen sulphide from brickfields and cement works; by organic vapors from glue refineries, bone-burning establishments, slaughter-houses, etc.; by the fumes of phosphorus,

to which lucifer-match makers are exposed, and the fumes of oxide of zinc, producing "brassfounder's ague."

58. Suspended animal, vegetable, metallic and mineral impurities cause an immense amount of suffering, the non-poisonous exciting lung disease by the irritation occasioned. After the age of thirty-five the metal miners of Yorkshire and Cornwall are liable to a large mortality from a disease commonly spoken of as "miners' rot." The lungs of colliers become black with coal dust. It may be well to enumerate a few of the trades which are injurious in this way. Potters suffer from the dust, and have what is called "potters' asthma." Knife-grinders are injured by the fine particles of steel, and suffer from what is called "knife-grinders' rot." Millers, sweeps, hairdressers and snuff-grinders are liable to asthmatic and bronchial affections. Button makers, pin pointers, cotton, wool and silk spinners, workers in flax factories, cotton weavers, stonemasons, grindstone and millstone makers and glass makers, makers of sand-paper and Portland cement, and men engaged in handling grain in elevators, all suffer from affections of the lungs.

Apart from the very obvious injury to health induced by inhaling dust of various kinds, the circumstances which attend the performance of these employments are in many cases highly deleterious. The hot, stuffy, damp, re-breathed air, in which large numbers of these artisans are bathed during their hours of labor, is enough in itself to predispose strongly to the development of disease.

59. Some of the metallic dust to which some workmen are exposed is poisonous. Manufacturers of white lead inhale the dust of this metallic compound. Plumbers, painters and printers often suffer from lead poisoning, in consequence in general of a want of sufficient cleanliness, the symptoms being persistent colic, and, in some instances, paralysis. These diseases are popularly known as "painters' colic" and "lead palsy." Printers also suffer from consumption, resulting from breathing air vitiated by unventilated gas-lights and respiration, their stooping posture when at work also aiding these injurious influences. Workers in mercury, such as silverers of mirrors and water-gilders, suffer from mercurial poisoning. Workmen and women who make arsenical wall papers, and artificial flowers, as well as those

engaged in the manufacture of aniline dyes, suffer from inhaling the poisonous dust of arsenical and other compounds.

60. Wall papers, clothing and furnishing materials are not exempted from the universal system of poisoning and adulteration that prevails. Many persons who are unwise enough to adorn their walls with arsenical papers of gorgeous hues, suffer and know not what ails them. Green tarlatans and some kinds of muslin are colored with Paris green. The bright green of certain furnishing materials, such as chintz curtains and linings, consist of the poisonous compounds arsenate of iron and chromium. Children have been poisoned by white arsenic, with which "violet powder" has been found to be adulterated, to the extent of 25 per cent.; and by lead, by inhaling the dust which proceeds from inferior kinds of "American cloth" with which perambulators are lined.

61. Pollen and the aroma of grasses will produce, in some people, hay fever.

The injury and fatality to life resulting from the pursuit of the callings to which allusion has been made, show the necessity of devising means for protecting from injury those who are obliged to engage in them. Even those who are not engaged in those injurious occupations suffer from breathing air loaded with dust, a mixture of particles of organic and inorganic nature.

62. Smoke, especially from factory chimneys, is also allowed to pollute the air. In cities an efficient system of street cleaning and watering would do much to prevent any considerable annoyance from dust, and a proper and careful system of stoking would completely do away with the black smoke nuisance.

63. Polluted sub-soil air often causes unhealthy emanations in the air of towns, and also in that of houses. It has been proved in England and the United States that the death-rate from consumption is diminished by drying the sub-soil. Rheumatism and heart disease, which is a frequent concomitant of rheumatism, are lessened by the same beneficial measure. Emanations from filthy soil produce diarrhœa in that portion of the year, namely, autumn, when there is a predisposition to intestinal disorders. It is very unwise to allow the soil close to houses to be defiled by filth, for the fires of a house creating a force of suction, draw into the house the air contained in

the surrounding soil, as well as that upon which it is built. The popular impression that the atmosphere ends where the ground begins, is a very widely spread delusion. Most soils are more or less porous. A house built on a gravelly soil stands on a foundation composed of a mixture of two parts of small stones and one part of air. The air may give place to any gas or to water. Instances are on record in which foul air from drains, cesspools and from leaky gas pipes has been drawn into houses great distances, and has caused ill-health and death from the continued poisonous condition of the air.

All the chemists who have investigated ground air are unanimous in the opinion that it contains more carbon dioxide than atmospheric air. Pettenkofer, of Munich, found that the carbon dioxide in the ground varied according to the season of the year; that it reaches its minimum from January to May, and then rises steadily to its maximum from July to November. The occurrence of the maximum in autumn is probably the result of high temperature and excess of decomposing organic matter.

64. **The air of churchyards and vaults** is richer in carbon dioxide than ordinary ground air, and contains often a putrid organic vapor, hydrogen sulphide, ammonium carbonate, ammonium sulphide, and elementary forms of animal and vegetable life.

The air of marshes contains also a large excess of carbon dioxide and organic matter. Carburetted and phosphuretted hydrogen gases are evolved by marsh land, and sometimes hydrogen and ammonia. The air of marshes is not at all times equally impure. Analyses of the air of marshes that are hot-beds of ague, taken on a fine day whilst a gentle wind blew over them, has shown that no more organic matter was present in such air than in pure air, collected simultaneously on high hills. This fact is only another proof of the purifying properties of air, and the tendency throughout nature, not only in the air, but in the earth and water, to self-purification and the restoration of an equilibrium.

65. **One of the effects of bad air** is the discomfort occasioned in those who are not habituated to its use. This discomfort is an evidence of positive injury, and may increase till headache, prostration of strength, disorder of the stomach, and fainting occur. Closeness of air not producing such marked symptoms may cause dyspepsia and

impairment of the general nutrition, symptoms which are now recognized as related to the development of consumption.

66. In the British army it has been shown by statistics that, previous to 1836, the mortality from consumption was very high, even where the troops were garrisoned in warm countries, such as Bermuda or the Ionian Islands. The Army Commissioners appointed by the Government to investigate the cause of this strange mortality among men who ought to be, under ordinary circumstances, in the prime of health and strength, considered that it was owing to the limited cubic space allowed to the men in barracks. Acting on this suggestion, the Government ordered that in future every soldier in barracks should be allowed 600 cubic feet of air space, and that suitable provisions should be made for ventilating the same. Although a space of 600 cubic feet is not as much as an adult man is entitled to, yet later army statistics show that the increased air space has exercised a favorable influence on the health of the soldier, and the mortality from consumption in all branches of the service is much less than it was before the improvement was inaugurated. Similar facts have been observed in most of the European armies. In the British navy, also, the mortality from consumption is much too large, forming an illustration of the way in which excellent climatic conditions, with nearly perfect arrangements in respect to daily life, may be vitiated by the one factor of bad air.

67. In civil life, also, statistics show a large mortality from consumption among classes of people who are obliged to breathe a foul atmosphere for a considerable portion of the day. Taking the last two reports of the Registrar-General of Ontario, viz., for 1882 and 1883, it is shown that among seamstresses the rate per cent. of mortality from consumption for 1882 was 59.2, and for 1883, 40.62; and among female teachers for 1882, 44.4, and for 1883, 57.14. The rate of mortality from the same cause among male teachers was, in 1882, 12.1, and in 1883, 29.26. The explanation offered in the report for 1882 for this discrepancy in the mortality from consumption between male and female teachers in Ontario is, "that the hardships incidental to a life of teaching weigh more heavily on females than males, especially in cities and towns where they have to encounter more densely crowded rooms, through a larger attendance of children,

than their fellow male teachers, the younger ones being invariably placed under their charge, and consequently their work is more wearing and exhausting. Their average age at the time of death was thirty-six, while that of male teachers was fifty-two years."

It has been already pointed out in the introductory chapter, that this disparity is in part due to the fact that many female teachers marry and cease to be professional teachers at an early age. Still, even after making due allowance for this, the mortality from phthisis among female teachers is excessive: the proportion of deaths from this cause to deaths from all causes amongst them being as 1 to 2.25, whilst the proportion for persons of all occupations is 1 in 7.13, and for persons of all occupations dying between the ages of 30 and 40 it is 1 in 3.08. In 1883 the disproportion is very much greater. In this year, also, the ranks of the male teachers suffered much greater losses from phthisis than in 1882.

An additional cause for the mortality amongst printers (Sec. 15) may be found in the fact that much of their work is done by gas light: the jets are not ventilated (as they might easily be), and each jet vitiates as much air as two men. Lamps are still worse.

Hospital gangrene, it is believed, can be entirely avoided by treatment in the open air or under tents. Camp-fever may be almost entirely banished by cleanliness and fresh air. Whenever such diseases as Asiatic cholera, typhus fever, diphtheria, small-pox, and the like, prevail, it has been universally observed that the mortality is much increased by overcrowding and foul air.

68. The diseases of childhood acquire increased virulence from bad air and overcrowding. In the four years ending in 1784, of 7,550 infants born at the ill-ventilated Dublin Lying-in Hospital, 2,944 died of epidemic disease; after a thorough system of ventilation had been adopted, only 279 died in the same number of years. At the same time tuberculosis was very common in the Dublin public institutions. Its cause was plainly overcrowding. Bowel complaints are prevalent among children during the warm season. This is not due to the heat alone, because a dry, pure air, like that of Arabia or Arizona, is found to be compatible with perfect health. They occur in close cities, where atmospheric moisture general filth, and an imperfect circulation of air, are associated with even a moderate amount of heat.

CHAPTER IV.

GENERAL PRINCIPLES OF VENTILATION—RULES FOR ESTIMATING VENTILATION.

69. **As the amount of carbon dioxide** is found to increase practically in an equal ratio with the amount of organic matter in re-breathed air, and as the proportion of carbon dioxide in any given sample of air can be easily determined, it serves as a measure of other and more dangerous impurities. It will, therefore, be proper to consider the amount of carbon dioxide given off by each individual in respiration, and the quantity of fresh air required to dilute this to a healthy standard.

70. **The amount of carbon dioxide exhaled** is computed by physiologists to be for a mixed community 0.6 of a cubic foot per head and hour. The amount of carbon dioxide in pure air has already been shown to be from .3 to .4 per 1,000, or 4 volumes per 10,000.

71. **The maximum amount of respiratory impurity** admissible in a properly ventilated air-space has also been proved by experiment (Parkes) to be 0.2 of carbon dioxide per 1,000 of air, making, with the 0.4 already in the air, the total impurity from this source 0.6 in 1,000, or 6 parts in 10,000 of air.

72. **The quantity of pure external air required** per hour by one individual inhabiting a room vitiated by respiration, in order to keep the carbon dioxide at a ratio of 0.6 per 1,000 of air may be calculated by the following formula (Parkes): $\frac{e}{p} = d$, in which e = the amount of carbon dioxide exhaled by one individual in an hour, p = the limit of permissible impurity (stated per cubic foot) in addition to that already in the air normally, and d = the required delivery of fresh air in cubic feet per hour. Now, if we take e at the general average of 0.6 of a cubic foot, then $\frac{0.6}{0.0002} = 3{,}000$ cubic feet of air required. This formula may also be used conversely to find from the condition of a

given sample of air the average amount of fresh air which has been hitherto supplied and utilized. For this purpose we substitute for p (the admissible limit), p_1 the observed ratio. Thus, let us suppose that p_1, the observed ratio of vitiation was 0.7 per 1,000 volumes, we should have $\frac{0.6}{.0007} = 857$ cubic feet of air per head and hour, which had been supplied and utilized during the time of occupation.

73. The quantity of carbon dioxide exhaled by an individual is not always the same, being greater when he is occupied than when in repose. It increases also in proportion to the body-weight of the individual, hence the quantity e must necessarily change. In the instance of adult males in repose $e = 0.7$ of carbon dioxide, and in that of children in repose, $e = 0.4$ carbon dioxide. The formula, therefore, by which we have shown that 3,000 cubic feet of fresh air are required per head per hour to dilute re-breathed air to a healthy standard is one which is suitable for a mixed community in a state of repose.

74. Active exertion of any kind, even singing, very much increases the excretion of carbon dioxide, and calls for a corresponding increase in the supply of fresh air. Thus, according to Parkes, for a man of 160 lbs. weight we should have :—

In light work... 0.95 of a cubic foot of Co_2 evolved per hour.
" heavy " ... 1.96 " " " "

This would argue a delivery of fresh air as follows :—

In light work .... 4,750 cubic feet.
" heavy " .... 9,800 "

75. The minimum amount of fresh air required in sickness ought to exceed that required in health by at least one-fourth. A sick person should, therefore, have at least 4,000 cubic feet of fresh air per hour, and the supply should be unlimited if the disease is of a virulent, epidemic character.

76. The amount required by the lower animals is a matter of some importance. It has been proved by the statistics of European armies, that an improvement in the condition of cavalry horses, and a diminished mortality among them, have been noted since their stables have been enlarged and ventilated. In civil life little attention is paid to this subject, and yet it is a fact of some interest to us that

cattle and other animals properly fed will thrive better in a well-ventilated place at a low temperature, than in a warm place ill-ventilated. There seems no reason why the same rule should not apply to animals as to men, in which case something like 20 to 25 cubic feet per hour per lb. of body-weight ought to be supplied.

77. The quantity required for lights will depend on the kind of light used. If no provision is made for the special ventilation of gas fixtures, fresh air must be supplied to dilute the products of combustion. A cubic foot of gas produces during combustion about two feet of carbon dioxide; sulphur dioxide and other noxious gases may also be formed. The carbon dioxide, which results from the combustion of coal gas, not being accompanied by organic matter, it has been computed by Holpert that 1,800 cubic feet of air are required to dilute the impurities caused by the combustion of a foot of illuminating gas; and as a common gas jet will burn nearly three feet of gas per hour, it will need as much fresh air as two men. The power of illumination being equal, illuminating gas does not produce more carbon dioxide than candles do, but usually so much more is burned that the air is more deteriorated; there is also greater heat and watery vapor. If gas is burned in small amount, or if only candles or oil lamps are used, it is seldom necessary to take them into account in estimating the amount of air. The electric light does not add any impurity to the air.

Having already shown that the limit of maximum impurity of air vitiated by respiration ought not to exceed .6 of carbon dioxide per 1,000 volumes, and that to ensure the maintenance of this standard 3,000 cubic feet of pure air must be supplied per head and hour, we must now consider the amount of cubic space which should be allowed per head in buildings which are occupied permanently or for a considerable portion of the day.

78. The size of the air-space allowed to each person must necessarily depend on the rate of speed at which air can be taken through it without the movement being perceptible or injurious. Generally speaking, it is found that the air of a room cannot be changed by what is called natural ventilation more frequently than three times per hour, consequently, if natural ventilation alone is used, each individual will require an air-space of 1,000 cubic feet. On the other

hand, if artificial ventilation is employed, so as to change the air in the room six times in an hour, a space of 500 cubic feet will answer. But there is an argument against a small cubic space, even with good mechanical ventilation, viz., that if anything arrests the mechanism for a time, the ratio of impurity from respiration increases much faster in a small than in a large space. Efforts should, therefore, be made to obtain a space of 1,000 cubic feet per head in buildings which are permanently occupied.

79. A suitable temperature and moisture of the moving air makes the problem of ventilation easier. At a temperature of 55° or 60°, air moving at a rate of 1½ ft. per second is imperceptible; a rate of 3 ft. per second is perceptible to most persons; and one of 3½ ft. is perceived by all persons; any greater speed than this will give the sensation of draught.

If the air be about 70° Fahr., a rather greater velocity is not perceived, while if it be still higher (80° to 90° Fahr.), the movement becomes again more perceptible, and this is also the case if the temperature be below 40° Fahr. If the air could be warmed to a certain point in a cold climate, or if the climate be warm, there may be a much more rapid current, and consequently a smaller cubic space might be given. The subject of ventilation is in cold climates connected inseparably with that of warming, for it is impossible to have efficient ventilation in cold weather without warming the air.

The degree of moisture of the air has also a modifying influence upon our endurance of draughts, a cool current being rendered more disagreeable by an excess, and a warm current by either an excess or deficiency, of moisture. In our systems of heating and ventilation the last named defect is altogether too prevalent.

80. The air supplied must be the pure external air, and care should be taken that air ducts are so constructed that they can be easily inspected. In towns the air may require to be filtered, as it is often loaded with smoke, soot, and other impurities.

81. The air may require to be warmed or cooled, according to the season or locality. The various methods of warming the air will be described later on. Allowing the incoming air to flow over blocks of ice is a very effectual method of cooling it during the hot season, but it may become too damp. Machines, however, have been invented

which have entirely superseded ice wherever set up, and they have been found to be more economical than ice at seventy-five cents per ton.

82. The sectional area of inlets and outlets should be so arranged as to furnish hourly to each occupant of a room 3,000 cubic feet of fresh air at a suitable temperature. Windows and doors may be utilized for this purpose in fine weather, but in cold or stormy weather, little dependence can be placed on these aids to ventilation. Dr. Parkes points out that a size of 24 square inches for inlet, and the same for outlet, for each individual, is the one best adapted to meet common conditions. This would permit the entry into a room of 3,000 cubic feet of air, with a velocity of 5 ft. per second at the inlet. In order that no unpleasant draughts may be felt from a current of this velocity, appliances, such as will be described hereafter, for breaking the current, would be necessary; and the initial air-space for each individual would require to be 1,000 cubic feet, otherwise the air could not be properly distributed before reaching the person. If, however, as should be the case in artificial ventilation, the inlets are 72 or 80 square inches in size per individual, the rate through them to supply 3,000 cubic feet of fresh air per hour would be only $1\frac{1}{2}$ ft. per second, which would be imperceptible even at the orifice. The outlets should be of the same size as the inlets.

83. The relative position of inlets and outlets is a vexed question. There are principally two plans of accomplishing the object in view, viz., that the pure incoming air shall pass by the breathing line of those who are in the room. By the first plan, the air properly distributed through a considerable number of inlets is made to enter the room at the floor line and, passing by the breathing line, escape at the ceiling. This plan may, in cold weather, be considered wasteful of heat; but it is used in buildings where the ventilation is excellent, as in the new one-story wards of the Boston City Hospital.

The second plan aims at sending the pure air, warmed or cooled according to the season, into the upper part of the room, so that it may descend by the walls and, passing by the breathing line, escape from the room at the floor. This plan is open to the objections that, in cold weather the air becomes rapidly cooled by being brought in contact with the walls, and that at night, unless special ventilation is

provided for the gas fixtures, the products of gas combustion are breathed by the inmates of the room.

84. In summer our endeavor generally is to secure the largest amount of cool air. There is also a necessity for a larger amount of air, as the amount of organic matter thrown off from the skin in the form of perspiration is much greater in summer than in winter, and calls for freer ventilation. On the other hand, however, the outer air is nearer the temperature of the body, and can be more freely admitted. Where rooms are fully occupied in warm weather, ventilation by the windows will not give a sufficiency of pure air to all the inmates. Pure cool air, admitted at the line of the floor, well distributed through numerous appropriately placed openings, and allowed to escape at the ceiling, seems to answer all the necessary indications.

85. In cold weather, on the contrary, our efforts are directed to securing warm air. We warm the air, but we do not usually provide for a sufficient access of pure air. One reason for this is, that we wish to economize fuel, experience having proved that a constant access of pure warmed air to our bodies requires the consumption of a large quantity of fuel. A second reason is, that we rarely provide sufficient outlet for the impure air, and, consequently, cannot expect the entrance of the pure air. Supposing, however, that we wish to have efficient ventilation in cold weather, the warmed air may be introduced at the floor in finely divided currents, well distributed, and allowed to escape at the ceiling; and this system of ventilation is quite as suitable in cold weather as in summer, owing to the operation of the law by which heated air constantly tends to rise. One remarkable advantage possessed by this plan is that the outlets do not require to be specially warmed, the impure heated air escaping from the uppermost outlet in the ceiling with great ease. To secure the best results from this plan, it is obvious that the incoming air must be so distributed at the floor line as to reach in its upward course the whole area of the room. As carried out in practice it is often imperfect, the warm pure air being impelled into a corner of the room with great force, and allowed to escape at the ceiling with reckless facility. When proper attention is paid to the distribution and breaking up of the incoming current of pure air, it works admirably.

Where the other plan is adopted, *i.e.*, the introduction of pure air at or near the ceiling of a room, the distribution of the air is simpler.

86. **The late Mr. W. R. Briggs** advanced some novel views on this method, which are embodied in a paper published in the third Annual Report of the State Board of Health of Connecticut, 1881. From this report we take, by permission, the following extracts, setting forth the results at which Mr. Briggs arrives :—

"The air entering upon the outer wall at the floor, and being removed on the inner wall at the ceiling-level, does not benefit the occupants of the room as it should. The action of the air as it enters is rapidly upward to the ceiling, where it stratifies, then along its surface to the outlet, as indicated (Fig. 7).

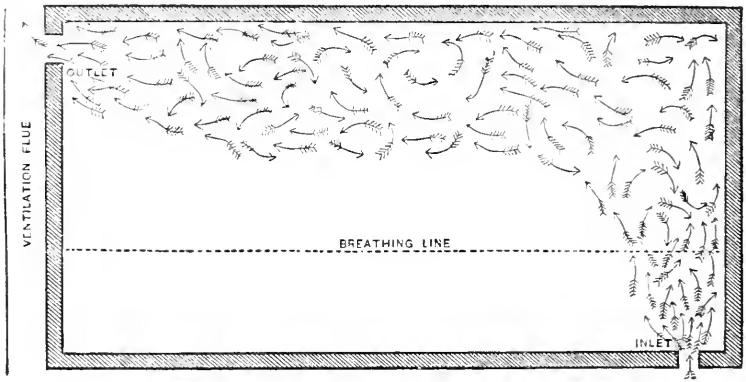


Fig. 7.

The entering air is warm and light, and naturally rises and flows across the top of the room to the nearest outlet. The foul air of the room, being heavy with impurities remains at the bottom, becoming constantly more contaminated. There is no doubt a certain amount of radiation or mixing is going on, but the great bulk of the pure warmed air entering the room takes the short cut across it and up the chimney, as shown in Fig. 7. This action of the warm air occasions, as may be readily seen, an enormous loss of heat, without accomplishing the very points aimed at, the utilization of every particle of heat before it is allowed to escape, and the thorough mixing of the pure incoming air with the air already in the room. If any one doubts the correctness of the action of air as herein described, let him fill the incoming flues with smoke, that can be readily seen, and watch its course as it enters, flows upward and outward, and see where the great mass of it goes. The dotted lines on this sketch indicate the breathing point of a person sitting."

"It may be well to explain that in these experiments the outlets have been at least *twice as large* as the inlets, and that there has always been heat in the outgoing flues to produce a strong up current, as I believe this to be the *only* sure way to produce a constant outflow of air."

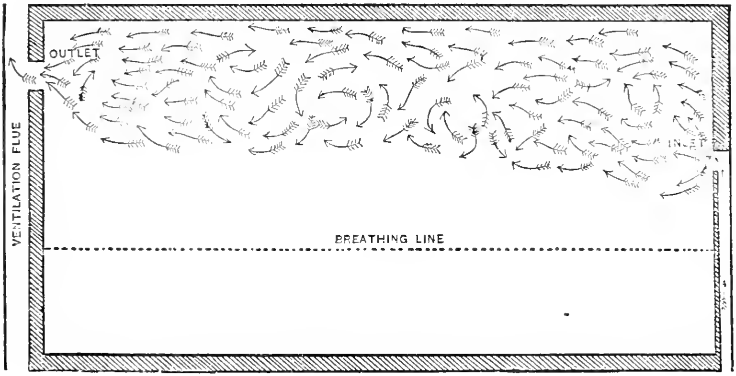


Fig. 8.

"In Fig. 8, the outgoing flue is in the same position, but the incoming flue has been raised about two-thirds of the way towards the ceiling."

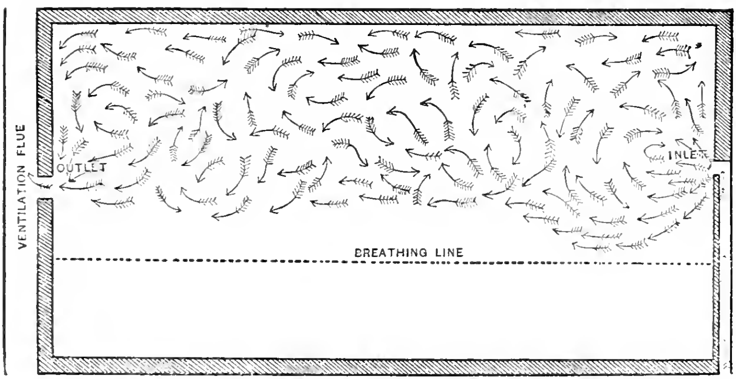


Fig. 9.

"In Fig. 9, the flues have been placed on about the same level, but with no better results."

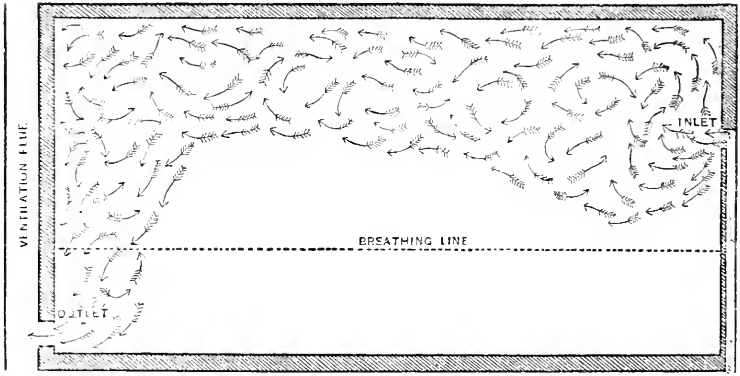


Fig. 10.

"In Fig. 10, the outgoing flue has been placed at the floor, with the results shown in the sketch."

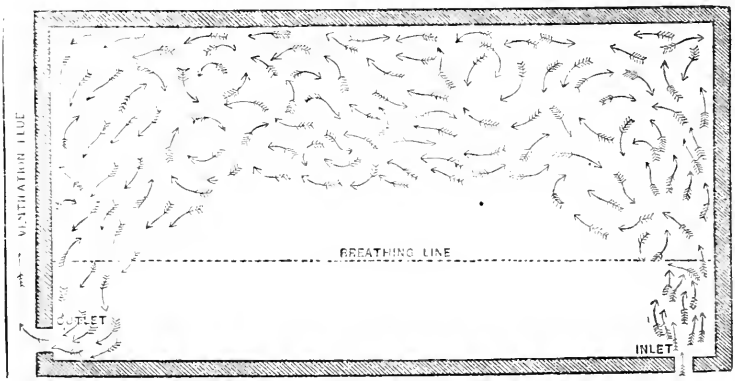


Fig. 11.

"In Fig. 11, both flues are at the floor level, with better results than have yet been obtained, but still far from satisfactory. I have thus tried to show the general action of incoming and outgoing currents of air by the placing of the introduction flues on the outer walls."

*   *   *   *   *   *

"In the Bridgeport School the coil-boxes for the heating of the various rooms have all been placed in the main ventilating shafts in the centre of the building, and the air conveyed from them through these shafts to the rooms by means of metal tubes. The air enters the inner corner of the room about eight

feet from the floor, the corner being clipped so as to form a flat service for the register opening; underneath the register the space is utilized for a closet for the use of the teacher. The outgoing flue has been placed directly under the platform, which is located in the *same corner* as the introduction flue. This platform measures 6′ × 12′, and is supplied with casters, so that it can be moved at any time it is necessary to clean under it. Its entire lower edge is kept about 4″ from the floor, to give a full circulation under it at all points. The action of the incoming air is rapidly upward and outward, stratifying as it goes towards the cooler outer walls, thence flowing down their surfaces to the floor and back across the floor to the outgoing register. By this method all the air

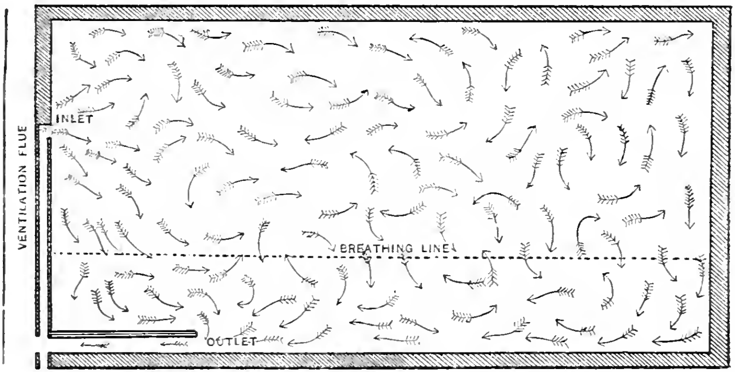


Fig. 12.

entering is made to traverse with a circular motion (see Fig. 12) the entire room, before it reaches the exhaust shaft, and there is a constant movement and mixing of the air in all parts of the room. All the heat entering is utilized, and I believe that if the supply and exhaust flues are properly balanced as to size, there can be a very small loss of heat."

"The inlets are all intended to be large, and the flow of air through them moderate and steady. The air is not intended to be heated to a very high temperature; the large quantity introduced is expected to keep the thermometer at about 68° at the breathing level."

If the system indicated in Fig. 12 is adopted, great attention will have to be paid to the proper heating of the flues, with which the outlet tubes are connected, and the outlets will require to be much larger than usual, and air-tight. Besides, the outlets would have to be all of equal length, otherwise the shorter tubes would draw better than the longer ones. Whichever plan is adopted, its value will have

to be measured by the ease, completeness, and cheapness with which it accomplishes the object in view.

87. The fresh air inlets should slope upwards, to prevent the entrance of rain or snow. They may communicate with the external air by means of perforated bricks or gratings, so as to divide the entering current and break its force, or they may be provided with a damper, by which the entry of fresh air can be regulated to any desired extent. It may be necessary to cover the orifices of these inlets with muslin or paper-hanger's canvas, in order to prevent the entrance of dust. They should be so constructed as to prevent unpleasant draughts.

88. Windows can be opened in mild weather for at least part of the day, and if raised at the bottom one inch and lowered at the top an equal amount, excellent ventilation can be secured with little danger of draught.

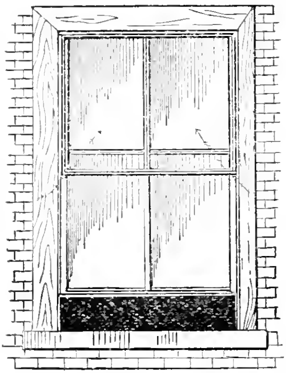


Fig. 13.—The lower sash is raised a few inches, and the space beneath is filled by a board; an upward inlet is thus made between the sashes.

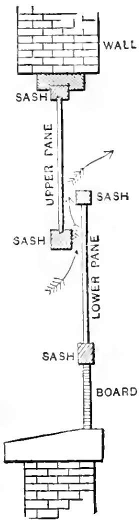


Fig. 14.—Sectional view of Fig. 13.

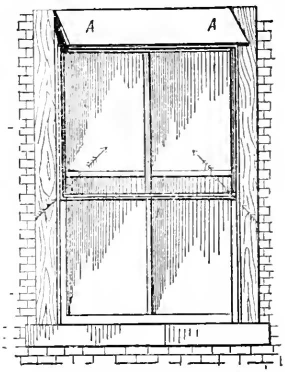


Fig. 15.—A board (*AA*) slanting downward and outward is affixed to the top of the window-frame, and the upper sash lowered; a second opening is thus secured.

89. The method suggested by Dr. Cotting of raising the lower sash a few inches and inserting beneath it a board the width of the window, secures a considerable ventilating space between the two sashes at their point of junction. (Figs. 13 and 14.)

A similar plan is that shown in Fig. 15. The opening at the top will act either as an additional inlet, or as an outlet, according to circumstances. It is protected by the slanting board (*AA*) in such a way that, if it act as an inlet, the air will not blow directly downward.

The adaptation of boards at the top and bottom of the window, by which a current of air in and out of the window is created, is also an excellent idea, which may be applied in practice at very little expense. Where the heating of a house is effective, this plan may be kept in operation during very cold weather.

90. All outlets, whether specially warmed or not, should be lined with some smooth substance, such as tin, or should be made of tile-pipe, so as to offer the least possible resistance to the outflowing air. They should be straight, circular in form, and surmounted by a cap, so placed as to prevent rain from entering, but not to interfere with the up-draught. They should not be built in outside walls, which are exposed to the weather, nor should they be lined with rough plaster, as they too frequently are. They should be carried up independently of each other through the roof into the open air; occasionally they may be made to converge in the attic to a large common outlet. They should be protected so as not to lose heat. They should be warm, at least as warm or warmer than the outer air, or else the current will be inverted. In dwelling-houses the heated chimney flue, with an open fire, is an excellent outlet, so good that in cold weather an open fire or two may with advantage be kept burning in inhabited houses, no matter what the system of heating may be. When rooms are large and more crowded, a greater number of outlets is necessary, and the heat of the fire may be further utilized by surrounding the smoke flue with outlets. In rooms where the construction of such flues has been neglected, neatly painted 4 in. pipes may be substituted. The lower end of the pipe should be funnel-shaped, and rest on feet 3 or 4 in. from the floor, in some convenient position. Its upper portion should turn by a curved elbow, and connect horizontally with the stove-pipe. The cold air is thus drawn from the floor.

91. Gas, if used, may be also employed to warm an outlet tube, with the double object of carrying off the products of combustion and of utilizing its heat. The best arrangement appears to be to place

over the gas jet a funnel and pipe to carry off the products of combustion, and to case the pipe itself with another tube, the opening of which is at the ceiling; the tube carrying off the gas products is hot enough to cause a very considerable draught in its casing, and thus two outlet currents are in operation, one over the gas and one from the ceiling around the gas tube.

92. Outlets should be kept clean, for in spite of all precautions air will occasionally pass down them. They should be free from angles, which very much impede the passage of air. They should be large, so as to diminish friction, and, for the same reason, unless well heated, they should not be long, for with equal sectional areas the loss is directly as the length, so that, if we take a shaft of thirty feet as a standard, a shaft of forty feet long would have an increased friction of one-third. The necessity of providing efficient outlets for impure heated air will be alluded to again, more particularly when we are discussing the various methods of warming buildings.

93. The terms natural and artificial are applied to systems of ventilation according as the forces which move the air are natural or artificial. Though convenient, this division is not strictly logical, as the forces which act in natural do also in artificial ventilation to a certain extent.

94. In natural ventilation the forces which act are: (1) diffusion, (2) the wind, and (3) the difference in weight between masses of air of unequal temperatures.

95. Diffusion aids in the purification of gaseous substances; but organic impurities which are molecular are not affected by it. This law of diffusion, which is in silent operation at all times, operates powerfully in preserving the equilibrium of the atmosphere.

96. The wind is a powerful ventilating agent; but it is uncertain in its action, and in cold weather it cannot be endured without tempering. When the wind passes through a room with open doors and windows we have most effective ventilation. Even when doors and windows are closed the wind will pass through walls of wood (single cased), and even of brick and stone; and perhaps this accounts for the fact that such houses, though cold, are healthy habitations.

97. The velocity of the wind in this country, except in very warm weather, is very great. The average mean annual velocity of the

wind at Toronto for the year 1879 was 10.36 miles an hour; for 1880, 10.54; for 1881, 9.91; for 1882, 10.42; and for 1883, 10.08. The month of greatest mean velocity from an average of 34 years is March. The month of least mean velocity from the same average is July. The greatest daily mean velocity for 1883 was 27.29 (on November 12), and the least daily mean velocity for the same year was 2.50 (on August 8). The anemometer used in making these calculations of the movements of the air is situated at a height of 76 feet from the ground. Formerly, when the anemometer was placed at a lower level, the average mean annual velocity of the wind at Toronto was quoted at 8.32 miles an hour in 1878, and 8.33 in 1877. The prevailing direction of the wind at Toronto is in summer west and east of south, in winter west and north-west.

98. The perflating power of the wind in this country is considerable, and it may be relied upon as an efficient means of ventilation. It is difficult, however, to regulate this force in cold weather, unless the incoming current of air is warmed before it is distributed. In summer perflation is our most efficient means of ventilation.

99. The aspirating power of the wind materially assists ventilation, because a moving body of air sets in motion all air in its vicinity, the surrounding air flowing towards it in a rectangular direction. In this way the wind blowing over the tops of chimneys causes a current at right angles to itself up the chimney, and the unequal draught in furnaces is owing in part to the variation in the velocity of the wind. Advantage can be taken of this aspirating power of the wind to cause a current of air in an outlet.

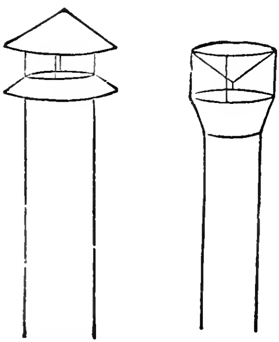


Fig. 16. Up-draught pipe. Fig. 17. Down-draught pipe.

100. Cowls placed over tubes tend to improve the draught. Thus a fixed cowl, consisting merely of a cone as a cap, and a similar flange around the rim of the pipe, insures a fairly constant up-draught (Fig. 16). A reversed arrangement insures a constant down-draught (Fig. 17).

Movable cowls are also constructed having vanes attached to them,

which turn the mouths of the cowls to or from the wind, according as a perflating or aspirating force is required, as shown in Figs. 18 and 19 respectively.

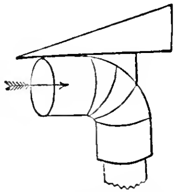


Fig. 18.—Revolving cowl, with down-draught or *perflating* action.

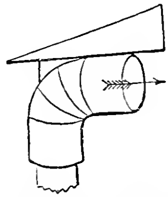


Fig. 19.—Revolving cowl, with up-draught or *aspirating* action.

101. The pressure of the wind sometimes prevents the exit of air from a particular opening by blowing down a chimney or a tube. Makers of cowls have taken great pains to overcome this difficulty, by giving different shapes to the cowls, but the shapes depicted in the diagrams are sufficient for every purpose.

The pressure of the wind when blowing at the rate of 10 miles an hour is equal to $\frac{1}{2}$ lb. to the square foot; in case an outlet were exposed to such a wind, ventilation through it would be clearly impossible.

102. The ventilation of ships is much facilitated by the use of cowls, by which the wind may be made to penetrate into the hold of a vessel or between the decks.

103. The difference of weight between masses of air of unequal temperature is the cause of the wind itself; but in discussing ventilation it is mentioned as an independent cause. When air is heated by any cause, viz., a fire, or the respiration of men or animals, or when it becomes moister, it endeavors to expand, and if it can escape a portion of it does so; the portion which remains will be lighter than an equal bulk of the colder air outside. The outer air will then rush into the room until the equality of weight inside and outside is re-established. But as the cold air which enters is in its turn heated, the movement is kept up as long as the source of heat continues in operation. This is the most useful agency in natural ventilation in cold weather.

CHAPTER V.

APPLICATION OF THE FOREGOING PRINCIPLES—WARMING.

104. In the practical application of natural ventilation nothing special is requisite to allow diffusion to act, except that there shall be communication between two atmospheres. This force acts to a very slight extent in the removal from a room of the impurities which result from respiration and combustion.

105. To obtain the perflation of the wind openings capable of being closed when necessary should be placed on opposite sides of a room. When double windows are used spaces may be left at the bottom of the outside sash and at the top of the inner one; double panes are sometimes used in the same way, so that the wind is obliged to pass up between the two windows or the two panes, as the case may be, before it enters the room.

106. Glass louvres, which can be more or less closed, are placed in one of the panes of the window where single windows are used, or a number of holes may be bored vertically in the lower part of the upper sash. The upper sash of a window should always be made to open, as well as the lower one.

107. Ellison's conical bricks, which are pierced with conical holes about $\frac{2}{10}$ of an inch in diameter externally, and $1\frac{1}{4}$ inch internally, depth $4\frac{1}{2}$ inches, are of service in permitting perflation. The wind blowing on them is so distributed as to be imperceptible as a draught in the room.

108. The Sheringham valve (Fig. 20) is an improvement on this; the air passes through a perforated brick or iron plate, and is then directed upward by a valve opening, which can be closed, if necessary, by a balanced weight.

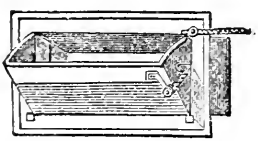


Fig. 20.—Sheringham valve.

A modification of this, called "the Eureka ventilator," is much used in Boston. These valves may be placed in the house wall opposite a heater, where direct radiation is used, to warm the incoming air before it is distributed.

109. Tobin's tubes have been much praised of late years. They are fresh-air tubes carried higher than the heads of the people in the room, so as to obviate any discomfort arising from down-draughts. In rooms with windows only on one side, this is said to be a convenient method of improving the ventilation.

110. The jacketted stove, with its method of receiving pure cold air, warming it and distributing it through the room, is a most effective, economical and convenient method, and may be readily introduced into houses which have been built without proper attention to the requirements of ventilation. It will be described when we come to speak of "Warming."

111. Stallard has proposed to ventilate factories and workshops by having a double ceiling; the lower ceiling is to be made of zinc or oiled paper, perforated with very numerous small holes, and the space between the two ceilings is to be freely open to the air on all sides; thus there would be almost open air breathing, as the communication with the external air would be constant and at all parts of the room.

112. Potts has invented a system of ventilation well suited for large rooms. It consists of a hollow metal cornice running continuously around the room, and divided longitudinally throughout the whole length into two separate channels, by a plate attached to the lower one. The fresh air is admitted through openings in the walls into the lower channel, and falls imperceptibly into the room through numerous perforations. The upper channel communicates either with the smoke flue or other air shaft, and receives the vitiated air through a series of small openings, similar to those of the lower channel. As the fresh air, being colder, descends by its own gravity, and the vitiated air, being warmer, rises to the highest point, there is no doubt that the principles of the system are correct. Mr. Robson, architect to the London (Eng.) School Board, strongly recommends it for facility of application to buildings originally erected without proper provision for ventilation, for sightliness, economy of first cost, and self-acting properties (Wilson).

113. Mr. H. Varley has proposed another plan, which has been found to work well in schools. A perforated zinc tube communicating with the external air, passes along the cornice on three sides of the room,

while on the fourth side another perforated tube is connected with the chimney which acts as the extraction shaft.

114. McKinnell's circular tubes consist of two hollow tubes, one within the other, and of such relative calibre that the transverse area between the tubes is equal to the sectional area of the inner tube. The inner tube is of slightly higher elevation than the outer, may be surmounted by an up-draught cowl, and acts as the outlet. The fresh air enters between the tubes, and is thrown along the ceiling by means of a horizontal flange surrounding the lower margin of the inner tube. Both tubes should be situated in the centre of the ceiling or roof. If there is a fire in the room both tubes may become inlets. To prevent this the outlet tube should be closed; if doors and windows are open both tubes become outlets. The movement of air by this plan is almost imperceptible. It suits round or square rooms or small churches; to very long rooms it is less adapted. The tube is made of all sizes from 6 inches in diameter, which is suitable for a sitting-room, up to seven or eight feet, which is the size used in some churches. The tube is also well adapted for guard rooms, cells and rooms of small dimensions, when it is desirable to have the ventilating apparatus out of reach.

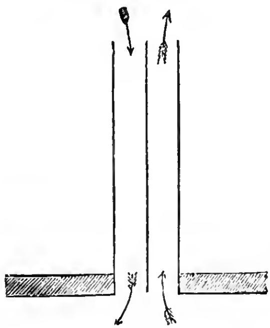


Fig. 21.—Watson's tube, with partition for inlet and outlet.

115. Watson's tube, a simple tube with a partition down the centre is here illustrated. (Fig. 21.) In this tube accidental circumstances, such as the sun's rays on one side, the wind, the fire in the room, etc., will determine which is outlet and which is inlet.

116. Artificial ventilation is effected in two ways; either the air is extracted from a room or building (*extraction*), or it is driven in so as to expel the air already in the room (*propulsion*). Extraction may be accomplished by various means, viz., by the application of heat, so as to cause an upward current, or by a steam-jet, by pumps, fans, archimedean screws or wheels, which draw out the air.

117. Extraction by heat is well exemplified in the common chimney with a fire-place. When the fire is burning there is a constant current of air up the chimney. The movement will be great or small, in

proportion to the size of the fire and the chimney. A kitchen or furnace fire causes a very free movement. If the area of the flue is known the discharge of air from it, as measured by the anemometer, may be stated in cubic feet. Grates, fire-places and open stoves of various patterns are simple plans for accomplishing extraction. Where these are used to heat rooms, the smoke flues should be surrounded by ventilating shafts having direct communication with the rooms. If a heated shaft is used to ventilate a building, steam-pipes passing to upper stories may serve the same purpose; a suitably arranged fire, or one or more gas-lights in the upper part of the shaft, will also furnish ascensional power. The gas-light may serve the additional purpose of lighting an upper hall or room. In theatres the chandeliers have long been used to promote extraction, shafts to and through the roof being built over the principal chandeliers.

Objections to this method of ventilation are frequently found to repose on the fact that an injudicious "economy" has interfered with the necessary consumption of fuel, and that the extraction being weak, the escape of foul air has been necessarily impeded. When flues or shafts are regularly warmed, insuring dryness, there is rarely any difficulty in securing a good upward draught and satisfactory extraction.

118. In extraction by the steam-jet the moving agent is the force of the steam-jet, which is allowed to pass into a chimney. This plan is suitable for factories with spare steam.

119. The archimedean screw ventilator has been recommended for small air-shafts, and has also been applied to large factories where it may be worked by steam power.

120. The fan has been used in mines to draw out the air through a shaft. At the Abercairn mine the fan has been made to extract as much as 45,000 cubic feet of air per minute.

121. The exhaust wheel may also be used to accomplish similar results. It may be used with advantage where for any special reasons it is necessary to have frequent renewal of the air. When a wheel is in operation in a room or building, the air is rapidly affected by the variation in pressure, and a movement is produced in every part. Such a wheel may be placed in a wall or window without the aid of a shaft. Ventilation may thus be made to work satisfactorily without creating strong draughts, the impure heated air being made to ascend

while the admission of pure cool or warm air is regulated by registers in the floor.

122. **Propulsion** as a system of ventilation was introduced in 1734 by Dr. Desaguliers. It may be carried on by means of a fan, enclosed in a box, which can be worked by hand, horse, water or steam power. The air enters through an opening in the centre of the box, and is thrown by the revolving fan into a conduit, which communicates with the different parts of the building. In France and the United States the fan is employed in the ventilation of many large buildings, the air being forced into a basement chamber, where it is heated or cooled according to the season of the year. In the Asylum for the Insane at Kingston, Ontario, fresh air is propelled into the building. In winter it is made to pass over steam coils before it is distributed. In some cases two fans are employed, one for propulsion and one for extraction. This plan is used in the New York Hospital, the Madison Square Theatre in New York City, and the Trocadero in Paris, France. Propulsion and extraction are thus used in ventilating the House of Commons at Ottawa, the extraction being accomplished by a heated flue at the ceiling, and by an exhaust fan, which draws away the air from the floor.

123. **The Madison Square Theatre** is one of the best ventilated buildings of its class. The air is taken in at a tower above the roof, and is sifted through a conical bag of cheese-cloth forty feet long, suspended in the tower; it is heated by steam in winter, and cooled by passing over ice in summer, four tons being required for each evening. One fan at the foot of the tower forces the air in; another on the roof exhausts it. The doors and windows are kept closed; heating, cooling and distribution take place in the cellar. The air is introduced by pipes running under the risers; an opening in the riser at each seat discharges a forward current with a velocity of two and a-half feet per second. Other jets enter at the front of the footlights and below the balconies. The outlets are chiefly under the balconies, so that there is a general movement away from the stage. It is thought that the acoustic effect is improved by this circumstance. The footlights are ventilated into a horizontal duct in which the gas pipe is laid, thus heating the gas before it is burned. The great dome light and the other gaslights are enclosed in glass and ventilated upwards. The

supply is 1,500 feet per head and hour; the theatre seats 650 persons, and has a capacity of 90,000 cubic feet.—(Lincoln). We have been thus particular in giving the details of the ventilation of this building, because the air in it is said to be sensibly as pure after a performance as before it.

124. The relative values of the different systems of ventilation are thus discussed by Hirter in Buck's "Hygiene." "Under all circumstances provision should be made for natural ventilation. In temperate climates, in most cases, especially for dwelling-houses and hospitals, natural ventilation, with such powers of extraction as can be got by utilizing the sources of warming and lighting, is the best. One of the chief objections to aspiration by heat, considered as a sole reliance, is the fact that it cannot be depended on for an emergency requiring a great but temporary increase of ventilating power. In cases where such emergencies are likely to arise, mechanical propulsion combined with mechanical aspiration deserves the preference. This combined system works with more certainty and constancy, delivers a better quality of air, is accompanied by fewer inconveniences, is easier to oversee, and in large edifices is cheaper than other systems in the same circumstances."

125. Artificial warming of houses is necessary for about seven months of the year in this country. All persons, however, do not require the same amount of artificial heat. Healthy, well-clad and well-fed young people and adults endure exposure to cold very well, and find it invigorating; the temperature of a house may, therefore, for them be regulated by what is comfortable. Young children and old people generally require a temperature of from 65° to 70° Fahr.

126. Sick persons are more likely to suffer from hot, impure air than from cold air. In febrile diseases, such as pneumonia, exposure to pure cold air is beneficial, so long as there is no direct draught on the person. The same remark holds good of consumption, in the treatment of which pure air is the principal requisite. Persons suffering from spasmodic diseases of the air passages, from chronic heart disease, and those who are convalescing from acute diseases, require a warm air.

127. Heat is communicated by radiation, convection and conduction. It is with the two modes first named that we are principally interested.

An open fire in a grate or fireplace is a good example of artificial radiant heat, as most of its heat is given off by radiation to the walls of the room, and to objects and persons in the room; very little by convection. This method of heating, therefore, does not add any impurity to the air, while it aids the ventilation of the room by providing an efficient outlet. The objections to its use in this country are its expensiveness and the fact that, at any considerable distance from the fire, its heating power is feeble, and that it does not heat surfaces which are not directed towards it equally with those which are so directed.

128. Stoves also radiate heat, but they principally heat the air by contact, the heated air being carried to different parts of the room by convection. As long as the air is not heated above 75° or 80° no harm is done, and the heated air is pleasant; but as soon as the air is overheated it acquires a peculiar smell, and is said to be burned. Such air is relatively dry, and absorbs water largely.

129. A hot-air furnace, with its fire-box, is analogous (so far as convection is concerned) to the case of a stove standing in a room. The furnace radiates heat to the walls of the box, which are usually of masonry, and the air becomes warmed by contact with the surfaces both of the furnace and of the box. If the furnace is not too hot, and the air is freely changed, the effect is pleasant. It is better, therefore, to have a larger stove or furnace than is actually needed, and to keep a moderate fire. This is true whether the room is heated directly or by registers.

130. Over-heating of the metal is of frequent occurrence with very many of the stoves in common use in this country. This over-heating of the iron, and the consequent spoiling of the air, may be prevented in two ways, viz., by placing an inner lining of fire-clay in the fire-box of the stove; or by constructing the stove with an outer casing of iron, with secure joints, so placed as to leave a stratum of air between the fire-box and itself. "Base-burner" stoves are thus protected. Some of them, however, are so badly constructed as to be very injurious from the escape of carbon monoxide and other injurious gases, producing the effects described in Chapter III. (see sec. 54, etc.)

131. Over-heating of air in furnaces may be prevented by providing liberal channels for the passage of air through the hot-air box and

correspondingly large apertures for its escape from the rooms. Thus large quantities of air are drawn through, and do not have time to acquire a great heat.

132. The quality of air supplied is much influenced by the construction of stoves or furnaces and their management. Thus, the products of combustion may escape from a stove or furnace of any description when the damper in the smoke flue is too close. A damper should never be placed in the smoke passage of an apparatus in use; it should be placed where the air enters the fire, not where it leaves it. Cast-iron furnaces, when they become red-hot, allow the products of combustion to escape into the room. A suitable material for making stoves or furnaces which shall be free from this defect exists in wrought-iron, which can be made perfectly tight by overlapping, riveting and hammering the edges. Soap-stone furnaces can be made tight also. The hot-air box and the cold-air duct should be made tight, so as to exclude cellar air. The supply of air for the fire and that for the air-box ought to be entirely separated from each other.

133. The proportion of inlets and outlets in a hot-air furnace is a matter requiring careful consideration. "The inlet for cold air in its smallest part ought to have a transverse sectional area of one-sixth of a square foot for every pound of coal (anthracite) burnt per hour in very cold weather; and the latter may be estimated at $\frac{1}{300}$ of the probable monthly consumption for average weather."—(Dixon.) For example, a furnace burning on an average two tons a month will burn in the coldest weather $\frac{4480}{300}$ = nearly 15 pounds per hour, which fixes the sectional area of the inlet at $\frac{15}{6} = 2\frac{1}{2}$ square feet = a space 18×20 inches square.

134. A current occasionally flows downward in one or another of a set of furnace ducts. We can sometimes trace the cause of this tendency; the phenomenon is analogous to one chimney sucking another where both connect with one room. It arises from a considerable disproportion between "the ascensional forces" in the tubes. A short duct entering a cold room might easily draw the cold air down into the furnace box, instead of sending warm air up. The remedy is furnished in part by so proportioning the size of the collective exits to the size of the inlets, that cold air entering at the latter expands in proportion to the greater capacity presented by the

outlets and not more. "The collective area of the hot-air pipes should not be more than $\frac{1}{6}$ greater than the least area of the cold air inlets, assuming that the heated fresh air is to enter the rooms at the temperature of about 120°, when at zero outside, and its velocity in the hot-air pipes not exceed five feet per second."—(Buck.) When a cold-air duct opens on the lee side of a house it has a tendency to convey its air in the wrong direction, or the in-draught is lessened. When it opens on the windward side it requires a slide to regulate the amount of air entering it. In some large buildings with many flues, the orifice is so exposed that the difference between the two sides is very troublesome. This may be remedied, as proposed by Mr. Tudor, by providing a receptacle of air of large size and convenient position into which ducts open from various sides in the walls; the supply is thus made constant.

135. The ventilating power of different stoves varies. The air required for the combustion of fuel is very small, and in the "air-tight" stove, where all superfluous currents are checked, is practically of no account in ventilating a room. The "open stove," the "Galton stove," the "fire on the hearth," are in a different category, and discharge nearly as much air as an open fire. The "fire on the hearth" is mentioned by Youmans as supplying with a small-sized stove over 10,000 cubic feet of air at 160° Fahr. in an hour, the outside temperature being 46°. It is a movable cast-iron stove.

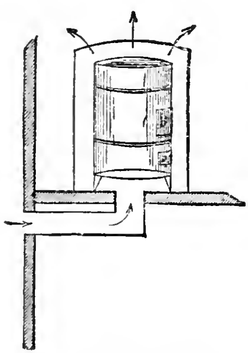


Fig. 22.—Jacketted stove.

136. In the jacketted stove the principle of introducing fresh air can be applied in a cheap and effective way by means of a cold-air flue from under the stove to and through the house wall, as represented in Fig. 22, where the stove is seen, surrounded by a cylinder of sheet iron, set on the floor. "The amount of fresh air thus introduced is abundant for domestic purposes, and not insignificant, though greatly inadequate, in the case of schools."—(Lincoln.) The success of this, as well as of other systems of introducing pure warm air, will greatly depend on the free and unobstructed action of theoutlets.

137. Converting the fire-place into a species of "Galton's stove" is a simple means of saving heat, and at the same time warming the air. For this pupose a tight flat chamber of masonry of no great depth and a few feet wide is to be provided in the space behind the mantel. (Fig. 23.) The heating surface may be increased by making the

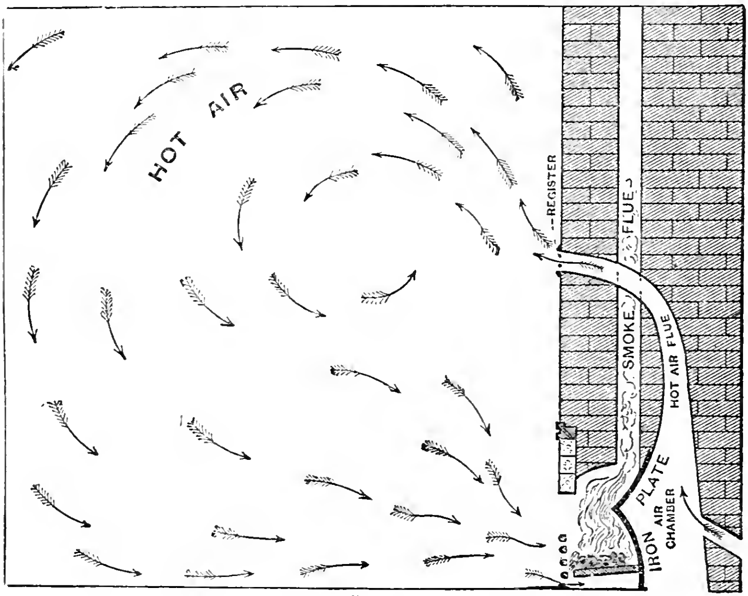


Fig. 23.

smoke flue from an open grate stove of ordinary pattern pass up and down in this space, making several (say four) bends, and exposing a great length to the air of the chamber, which then enters the room from a register. Fresh air is supplied to the chamber by a flue communicating directly with the outer air.

138. Heating by steam "is becoming popular in this country, even for dwelling-houses; while for public buildings it possesses certain distinct advantages. A steam apparatus is compact and easy to manage. It can be put in operation quickly. It transfers heat to any desired distance in a horizontal direction; whereas air from a furnace cannot be distributed over a radius of more than forty feet.

4 It is easily managed by any intelligent domestic. The heat in different parts of the building can be regulated by the size of coil, even in distant parts.

"It is contended that a careful grading of the steam pipes from the top to the bottom of the system, by which all condensed steam would flow back to the boilers, would prevent the disagreeable noises emitted by the steam pipes. All danger of explosion should be removed by obliging manufacturers of steam apparatus to furnish boilers which would stand a much higher rate of pressure than they will ever be subjected to. The ordinary application of steam to heating purposes consists in placing coils in the rooms to be heated without provision for the entrance of fresh air. Frequently no provision is made for the escape of heated impure air. All this is extremely objectionable. The proper arrangement would be to enclose each coil in a box, each box having an inlet for fresh air, and an outlet to discharge it into the room. Such a box can be arranged under the window seat without occupying much space. The same principle can be applied to boxes placed in the basement of a building. A flue or an open cellar window permits any desired amount of fresh air to flow through the coil. In distributing the air from such a heater, pipes and registers are used as in the case of furnace air. No introduction of fresh air, however, can take place unless there be an outlet for its escape from the room; and as things go, it is not safe to take it for granted that any ventilating flues are in working order except that surest of ventilators, the chimney and open fire-place. In a general way, it must be said that no room is fit for habitation unless it has a chimney."—(Buck.)

139. **Heating by water** "may be placed by the side of steam-heating. It gives a less intense heat than the latter, as the temperature of the air in contact with water-pipes does not usually rise above 113° Fahr. Its drawbacks are the slowness with which an apparatus is usually heated when once cooled down, and its comparative expensiveness. The surface of tube required is greater than in the case of steam-heaters from one-half to one-fourth. Many competent judges have expressed a preference for this system of heating. The principle which governs the circulation in a system of hot water pipes is based on the laws of gravitation. A circle of pipe, entering a furnace on

one side, is more heated at that side, and the water in that part rises, while the water in the other parts, being cooled, passes in to fill its place. The principle is quite the same, whether a simple circle is used or whether at various points the pipe enters a "coil" or a tank of whatever shape for the distribution of heat. Nor is the case affected by the use of a boiler in some systems and of a series of pipes in contact with the fire in others. It is essential that a point should be left open to the air at the high level, to give room for the expansion of the water and the escape of steam or heated air. This point may be, and usually is, at a tank."—(Buck.)

140. Greater attention should be paid to temperature, and every dwelling-house and every school-room should have a reliable thermometer—for use, and not for ornament only. The temperature most generally suitable in Canada is about 65° Fahr., and it should not be allowed to run over 70° nor below 60°. There are some persons who do not appear to understand the difference between *cold* air and *fresh* air: the temperature should not be maintained by closing outlets and preventing the changes which are necessary to keep the air pure.

141. The Moisture which should be present in a healthy atmosphere is often deficient in the air of a room heated artificially; every heating apparatus ought to be supplied with an arrangement for evaporating water. Experience shows that the result is both agreeable and beneficial; but in our anxiety to accomplish this desirable end we should be careful not to run to the opposite extreme. A rough, but efficient, method of determining whether we have reached the point of overloading the air with moisture is that of watching the window-panes—those of the outer windows, if there are double windows. The cold outside air will give us the "dew-point" sufficiently long before the air of the room has reached the point of saturation.

CHAPTER VI.

EXAMINATION OF AIR AND OF THE SUFFICIENCY OF VENTILATION.

142. If an examination of the sufficiency of ventilation should be required in any particular case, the following method may be adopted:—

(1) Determine the amount of cubic space assigned to each person, the relative size and position of inlets and outlets, the distribution of the air, and the number of cubic feet of fresh air which each individual receives per hour.

(2) Examine the contained air by the senses.

(3) Examine the contained air chemically.

(4) Microscopically, for suspended impurities.

(5) As regards temperature, moisture, etc.

143. To obtain the cubic measurement of a room the three dimensions of length, breadth and height are multiplied together. Where rooms are regular in form this is a simple process; but where they abound in angles, projections, half-circles, etc., the rules for the measurement of the areas of circles, segments, triangles, etc., must be adopted. After the room has been measured, recesses containing air should be measured and added to the amount of cubic space; and, on the other hand, solid masses, such as furniture, etc., which take the place of air, must be deducted from the cubic space already measured. The allowance for each bedstead and bedding may be estimated at ten cubic feet, and the space occupied by the body of each person at three cubic feet. In linear measurement it is convenient to measure in feet and decimals of a foot, instead of in feet and inches.

144. The relative size and position of inlets and outlets, such as doors and windows, and how they assist in the ventilation of the room, should be noted. If there be a fire-place in the room, its sectional area at the throat should be ascertained. If the system of ventilation is artificial, the doors and windows should be closed, and the movement of the air should be examined through the other openings. The direction of the movement may be ascertained by

observing the smoke proceeding from burning feathers or cotton velvet. The direction being known, it will suffice to measure the discharge through the outlets, as a corresponding quantity of fresh air must enter through the inlets.

145. The anemometer, or air-meter, is an instrument used in determining the rate of the movement of air through an opening. It may be described as a miniature wind-mill. The little sails driven by the air-current set in motion a series of small cogged wheels, which move several indices on a dial-plate. The velocity of the current can thus be read off for a given time, in the same way as the amount of gas which has been consumed is ascertained from a gas-meter. An instrument of this character has been constructed by Mr. Casella, of Hatton Garden, London (Eng.), with indices on the dial-plate indicating the velocity of an air-current in feet, hundreds of feet, thousands, etc., up to millions. By moving a catch the machine may be stopped at any moment.

146. The method of using the anemometer may thus be described. Before using the instrument the relative positions of as many of the indices as may be deemed necessary are noted. When the instrument is placed in the air-current, time is called, and the catch is moved to set the machinery free. At the end of a pre-determined period, time is again called, and the machinery immediately stopped by means of the catch. The amount, which was noted before the instrument was used, is then subtracted from the amount which appears on the dial-plate, the necessary correction* for the instrument made, and the product will be the linear dimension of the current for the time fixed upon. If this amount is multiplied by the sectional area of the opening, the volume of air which has passed through in the same time can be calculated in cubic feet.

When the anemometer is used in a tube or shaft, it should be placed well in, but not quite in the centre, because the velocity of the current in the centre is greater than at the sides of the tube. Should the shaft be large, the rate of movement ought to be taken at different

* Instruments are generally accompanied by a slip stating the number of feet which are to be added to, or subtracted from, the reading on the dial, as this rarely indicates the exact measurement. These corrections have been ascertained by comparison with a standard instrument. It is well that the test of accuracy should be repeated by a comparison of instruments when opportunity offers.

parts, and the average ascertained. So, also, when the rate of movement is irregular, several observations should be made, and the average of the whole of them will give the approximate velocity of the current.

"If placed in a tube very little larger than the instrument, the result cannot be depended on, and when placed at the entrance of a tube—for example, against a perforated air-brick or grating—the velocity of the current indicated by the anemometer is considerably less than what exists in the tube. In these cases the instrument should be exactly fitted into an opening in a box large enough to cover completely the mouth of the tube, by which means the whole of the air passing through the tube may be made to pass through the opening in the box."—(Wilson.) As we have already stated, after having ascertained the direction of an air-current in a room, it suffices to obtain the cubic discharge at the outlet.

If there should be no other air outlet from a room except through the chimney, the anemometer cannot be used when fires are burning in a room, as it would be injured by the heat and dust.

147. The manometer is an instrument which has been constructed to meet such an emergency. It is intended to measure the pressure, and, by calculation, the velocity of the air. The current of air is allowed to impinge on a surface of water, and the height to which the water is thrown up a tube of known inclination and size gives at once a measure of force. This instrument, necessitating a little calculation, is less useful than the anemometer. In practice it might be connected by a long tube with a distant room, and, thus constructed, would be well fitted to measure constantly the velocity in an extraction shaft.

148. Examination of the contained air by the senses gives tolerably reliable results; but it must be made immediately after coming from the open air. The following selections from the report of Dr. de Chaumont's experiments show how closely the sensations accord with the different degrees of impurity, indicated by the percentage of carbon dioxide.

At .14 in 10,000 parts......	Extremely close and unpleasant.
" .10 " "	Extremely close.
" .09 " "	Close.
" .08 " "	Not very foul.
" .06 " "	Not very close.
" .05 " "	Not close.

It has been remarked that moisture, even more than a rise in temperature, exercises a very marked effect in making organic matter more perceptible to the sense of smell.

149. The amount of carbon dioxide found in air is taken as a convenient measure of all impurities. There are several methods of detecting its presence and calculating its amount in any given sample of air. The method known as *Pettenkofer's* is a good one, but requires the expenditure of much time and labor. It consists essentially in washing a certain measured quantity of air with a definite quantity of lime water or baryta water, and noting the loss of causticity that either of these waters (whichever is used) has undergone; in other words, the amount of lime or baryta that has united with the carbon dioxide. This process is fully described in Parkes' "Hygiene."

150. The late Dr. Angus Smith's "household process" is a simpler, though somewhat less accurate, mode, sufficiently exact, however, for all practical purposes. It may be expressed as follows :—

"The outside air contains an amount of carbon dioxide varying between .03 and .06 per cent., but is most frequently .04 per cent., which rises in crowded buildings and other close, ill-ventilated places to 25 per cent. The way to estimate the amount roughly is to wash different measured quantities of air with ½ oz. of lime water" in bottles made specially for the purpose, and corked, and noting the size of the bottles in which a precipitate is just perceptible. It will be evident to the reader that it requires the same absolute amount of carbon dioxide to form a precipitate if the same quantity of lime water (½ oz.) is used in such case; and if it be found that it takes a large bottleful of air to supply this amount of carbon dioxide, this will indicate that the air is purer than if the amount of carbon dioxide were furnished by a smaller bottleful. "The lime water is prepared by slaking lime with water, stirring the slaked lime in the water, and then allowing the lime to subside. The clear fluid is, after 12 or 24 hours, poured off, and is ready for use." A table has been prepared to facilitate the use of this plan: having noted the size of the smallest bottle (filled with the air under examination) in which ½ oz. of lime water or baryta water may be shaken without giving a precipitate, we look for that size in the left-hand column; opposite to it, in the right-hand

column, will be found the proportion of carbon dioxide in the given sample of air:—

Size of bottle in ounces.	Proportion of carbon dioxide in air.
20.6	.0003
15.6	.0004
12.5	.0005
10.5	.0006
9 1	.0007
8.0	.0008
7.2	.0009
6.5	.0010
6.0	.0011
5.5	.0012
5.1	.0013
4.8	.0014
4.5	.0015
3.5	.0020
2 9	.0025
2.5	.0030
2.0	.0040
1.7	.0050
1.5	.0060
1.3	.0070
1.2	.0080

151. The point of most general interest to remember is, "that the air around houses generally contains about .04 per cent. of carbon dioxide, and that our rooms should always be kept so that a $10\frac{1}{2}$ oz. bottle, full of air, when shaken with $\frac{1}{2}$ oz. of lime water, gives no precipitate. We then know that the air does not contain more than .06 per cent. It is often difficult to keep the air of a room below .07. If a precipitate is observed, we know that the air does contain more than .06 per cent., and we take a smaller bottle, say a 9 oz. bottle, the air of which, when shaken with $\frac{1}{2}$ oz. of lime water, gives, perhaps, no precipitate. We then say the air is worse than .06, and not worse than .07; accordingly the amount must roughly be .07. If we wish to test the air as expeditiously as possible, and are not particular to obtain the exact percentage, we may take a bottle of a size indicative of alternate hundredths. Instead of taking a 9 oz. bottle, we may take an 8 oz., and treat 8 oz. of air in the same manner. If we obtain no precipitate, we know that the air is not worse than .08 per

cent. Having already ascertained that the air is worse than .06, we conclude that the air is contaminated with .07 or .08 per cent. of carbon dioxide."

"If no turbidity is occasioned on commencing with our $10\frac{1}{2}$ oz. bottle, and we would like to know whether the air contains as much as .06 per cent., we must take a larger quantity of air—for example, a $12\frac{1}{2}$ oz. bottle. If, when this quantity of air is shaken with $\frac{1}{2}$ oz. of lime water, no precipitate is procured, we know that the air does not possess more than .05 per cent., and if a precipitate is occasioned, we know that .06 per cent. is the amount."

"The air to be examined is best introduced into the bottles by sucking out the air already contained in them with a glass tube. Fresh air enters to supply the void we create. The greatest care should be taken not to breathe into the bottle, for our breath is full of carbon dioxide. The bottles should be wide-mouthed, so that the sides can be wiped dry and clean. If the lime cannot be readily removed, they should be rinsed out with strong muriatic acid, followed by an abundance of water. There is great difficulty in obtaining bottles of exactly the capacity required, but this could be overcome if there was any demand for such measures, by the special manufacture of bottles to hold the quantities of air indicated."—(Dr. Fox, "Sanitary Examinations of Water, Air and Food.")

Another way to insure the bottles being filled with the air of the room, is to fill them with water and then empty them in the room. The lime or baryta water should be poured in in such a way as not to be acted upon to any great extent before entering the bottle.

152. Of the chemical composition of the organic matter of the air very little is known. The methods of analysis which are at present most generally followed aim at converting the organic matter of the air into ammonia, the amount of which can be easily calculated. The organic matter has been obtained for examination from air by collecting the moisture, that is seen to attach itself to the walls and windows of crowded, ill-ventilated halls, which has been condensed by the cold air outside. Mr. A. H. Smee employs a glass funnel drawn to a point, and filled with fragments of ice. The moisture in the air is deposited as a dew on the sides of the funnel, runs down, and is

received in a vessel underneath. (Fig. 24.) This air moisture is examined for nitrogenous compounds, by the Wanklyn, Chapman and Smith process, in a manner similar to the mode in which the organic matter contained in water is detected and estimated.—(Dr. Fox.)

A number of other methods are described in Parkes' "Hygiene."

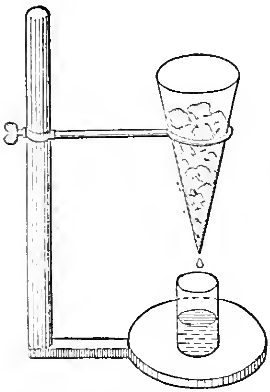


Fig. 24.—Smee's instrument for collecting moisture of the air for analysis.

153. The microscopic examination of the dust of the air has received great attention of late years. Dr. Parkes thinks it is probable that in future the microscopic examination of air will give more important information even than the chemical examination. The air may be collected by Pouchet's aeroscope; or a good method is to take a small bent tube, wash it thoroughly, dry it, and heat it to redness; when cool it should be placed in a freezing mixture, an india-rubber tube fixed on one end, and air slowly drawn through; the water of the air condenses in the tube, and many of the solid particles fall with it. A drop is then taken by a perfectly clean glass rod, previously heated to redness, placed on a clean glass, and looked at with an immersion lens as soon after collection as possible. Or air may be drawn through pure distilled water, a drop of which is then examined.

154. "An aspirator to draw air through the tube is easily made: a square tin vessel, with a tap below and a small opening above to receive the india-rubber tubing, is all that is necessary; fill this with water and let it run down, and measure the total quantity (in a pint vessel) discharged without tilting the vessel. An imperial pint contains 34.659 cubic inches, and one fluid ounce 1.733 cubic inches. A cubic foot is very nearly 1,000 fluid ounces, and the ounce may be taken as 1.728 cubic inches. The exact delivery of the aspirator is, therefore, easily determined; the air should be drawn slowly through the bent tube in the freezing mixture or through the aeroscope, so that no particles can escape."—(Parkes.)

A jar or can, fitted with a large cork, through which two pieces of

glass tubing pass, one reaching to the bottom of the can and the othe barely through the cork, one of them forming an outlet for water and the other an inlet for air, will answer the same purpose.

155. **A very cheap and good imitation of Pouchet's aeroscope** may be made as follows :—Take a small box (a salt cellar will answer) about $2\frac{1}{2}$ or 3 inches long, 1 or 2 inches wide, and the same in depth. Place in the bottom a slide smeared with glycerine; fit to it an air-tight cover of thick rubber, cork, wood with waxed edges, or other similar material. Let two little pieces of $\frac{1}{4}$ inch glass tubing pass through this cover obliquely, in a direction from the outer ends on top towards the centre at the bottom, one of them impinging on the slide above mentioned. Connect this tube with a funnel and the other with the aspirator. The air will be drawn through this box, and the particles will adhere to the glycerine on which the air impinges. The glycerine used should be pure, and carefully kept from dust, and should be previously examined to see that it is free from particles.

156. **A judicious use of thermometers** throughout the space to be examined will be found useful in estimating the capability of a system of heating as applied to a room or building. Such tests of heating power, in order to be as complete as possible, should be made during very cold weather, and in the night time; a comparison of the outside with the inside temperature should be made at the same time. Wher. the air is heated by an open fire-place, it will not do to be satisfied with a record of the temperature taken near the fire, to the exclusion of the remoter portions of the room. Again, when the air is heated before entering, it is necessary to take the temperature at the points of entrance and exit, as well as in various other portions of the room so as to see whether the warm air is well diffused or not. Every thermometer should be numbered and graduated on the stem, and should be verified by comparison with a standard instrument.

157. **The amount of watery vapor** in the contained air, or its hygrometric condition, may be determined by the wet and dry bulb thermometers. These last are to be considered as one instrument, generally called Mason's hygrometer. Mason's hygrometer consists of two verified thermometers fixed side by side, the bulb of one being always kept damp by a covering of muslin, connected by means of a lamp-wick with a little reservoir of distilled water. The finest muslin,

which generally contains starch, should be boiled in distilled water to extract it. Lamp-wick should be boiled in distilled water and a little carbonate of soda to remove all grease. The smallest thread of lamp-wick that will keep the muslin permanently damp should be employed, and the little reservoir of water should be fixed away from the bulb, so as not to create a local artificial climate. If the air is saturated with moisture there is little, if any, difference between the readings of the dry and wet bulb thermometers. The readings of the wet bulb are, as a rule, lower than those of the dry bulb thermometer. The generally accepted statement that, the greater the difference between the dry and wet bulbs, the less is the amount of watery vapor present in the air, requires some qualification. An increase of temperature by expanding the air, and thus separating the particles farther from each other, increases, whilst a fall of temperature, by drawing them closer together, diminishes the capacity of the air for moisture. Air of a temperature of 57.2° dry bulb, and 51° wet bulb, with a relative humidity of 64, may contain exactly the same amount of vapor in grains per cubic foot (3.4) as air of a temperature of 70.5 dry bulb, and 56.8 wet bulb, with a relative humidity of 42. The semi-diurnal rise of temperature is more frequently accompanied by an increased capacity of the air to absorb moisture than an actual increase in its amount. The relative humidity of, or percentage of moisture in, the air is ascertained by reference to Glaisher's hygrometric tables, adapted to the dry and wet bulb thermometers. In carrying out experiments in ventilation, hygrometers should be distributed in the room to be examined some two or three hours before the observations are made. The relative humidity of the air out of doors should also be ascertained at the same time, by way of comparison.

158. In a room well ventilated and well warmed the temperature should not fall below 60° Fahr., the carbon dioxide should not exceed 0.6 per 1,000 volumes, and an endeavor should be made to have a humidity approaching 70 per cent. But if care be taken to introduce fresh air regularly, it is quite possible to have good ventilation in rooms where a much lower percentage of humidity is found.

CHAPTER VII.

CLIMATOLOGY: TEMPERATURE—LIGHT—MOISTURE—SOILS—VEGETATION—WINDS—ELECTRICITY—OZONE—ALTITUDES—HEALTH RESORTS.

159. **Distance from the Equator** is the chief cause in distinguishing climate. The latitude of a place is generally considered the principal circumstance in determining its temperature. The general rule of distribution of heat over the surface of the earth in accordance with geographical position is, however, subject to many exceptions arising from local circumstances.

160. **Elevation of the surface** is one of the chief of these. It is a well-known fact that near the Tropics and the Equator there are mountains which, owing to their great elevation, are covered with snow all the year round. The heat experienced in a given place not only depends on the greater or less obliquity of the rays of the sun, but also on the greater or less column of the atmosphere. The column of air is greatest on the surface of the sea, and in such countries as are nearly on a level with it. The higher we rise the more the air is rarified, and the degree of heat due to the action on it of the sun's rays decreases. Thus we arrive at last at an elevation where the heat, even under the Equator, is insufficient to melt the snow.

161. **Other conditions,** in addition to temperature, operate powerfully in determining climate. Some of these are moisture, nature of the soil, and prevailing winds. To these may possibly be added electrical condition.

162. **As regards temperature,** climates may be classified into (*a*) equable, limited, or insular climates, with slight yearly and daily variations; (*b*) extreme, excessive, or continental, with great variations.

163. **The effects on races of a lower mean temperature and greater variations** than they have been accustomed to, have been tested by the experience, for more than a century, of immigrants from Great Britain and Europe to the various provinces of this Dominion, where health has not only been sustained, but frequently improved, and where the progeny has been as vigorous as that of the parent race.

164. Extreme depression of temperature tends to produce a torpor of the mental and physical faculties which, if yielded to, results in death. By its action in depressing the vital powers and constringing the minute blood vessels near the surface, cold gives rise to congestions and inflammations. Apoplexy, from this cause, is of more frequent occurrence in winter than in summer; bronchitis, inflammation of the lungs and of other organs, diarrhœa and rheumatism are often produced in this way.

165. The effects of extreme heat are strongly marked. When continued for any length of time diseases of the liver, diarrhœa, dysentery and fevers are induced. The effects of the sun in very hot weather on persons engaged in out-door work, or on soldiers on the march, have often been of a very serious character. Sun-stroke, producing congestion of the brain, and a peculiar effect on this organ and on other parts of the nervous system, is often the result of intense heat, especially when prolonged fatigue has been endured.

166. The effect of the direct rays of the sun requires consideration. Do they aid or check perspiration? That the skin gets dry there is no doubt, but this may be from evaporation alone. If, however, the nervous currents are interfered with, the perspiratory vessels and the amount of secretion are sure to be affected in consequence. If this is carried beyond a certain point, the heat of the body must rise, and, supposing the same conditions to continue, viz., radiant heat and want of perspiration, it must pass beyond the limit of the temperature of possible life, viz., 113° Fahr.

167. That intense heat acts fatally by destroying the muscular energy of the heart and diaphragm, or midriff, appears to have been proved by experiments of the late Sir Benjamin Brodie on the lower animals. The effects of a high degree of atmospheric heat are witnessed on a large scale in the deserts of Africa and Arabia, where caravans of travellers so frequently suffer from long exposure to a burning sun, and quite recently in the case of the British troops engaged under Sir Gerald Graham in the Soudan.

168. Of rapid changes of temperature, the exact physiological effects have not as yet been satisfactorily traced. These vicissitudes must be met by altered clothing: persons should dress, not for the season of the year, but for the existing condition of the weather. A sud-

den checking of a profuse perspiration by cold winds may lead to catarrh, inflammations and neuralgia. Great changes of temperature, however, in high altitudes such as at Denver City, Colorado, or at Davos Platz, in the Upper Engadine, Switzerland, may be, and often are, borne without ill effects, even by consumptives, who, either in carriages or walking, are out in the open air a large portion of the day.

169. **Sunlight** is essential to the full development of animal and vegetable forms. Plants deprived of its influence become blanched and stunted. Animals are similarly affected. The tadpole develops into the frog very slowly or not at all if kept in darkness. Professor Milne Edwards, in his work on the "Physical Agents of Life," records experiments on this point. He came to the conclusion that the action of light is to develop the different parts of the body in that just proportion which characterizes the type of the species. It is almost invariably the case that those parts of animals nearest to the ground, and consequently least under the influence of light, are white or colorless. The brilliant colors which belong to the plants and animals of every kind found in the tropics are doubtless due, in part at least, to the influence of sun-light. The importance of light in a hygienic point of view is not sufficiently estimated by most persons.

170. **Individuals deprived of it** from an early age are generally of a low vital power. The offspring of such are frequently deformed, and are always weak and puny. From the observations of those who have given attention to this subject, there appears to be no doubt that scrofula is often produced in children by the deprivation of the sun's rays. Professor Lombard, of Geneva, very truly says that light stimulates, and darkness impedes, respiration, and, through respiration, animal heat and muscular activity.

171. **Etiolation** is the term often applied to the condition of persons deprived of the sun's rays, and is well described by Riembault in his "Hygiene des Ouvriers Mineurs." According to this author, it is characterized by a diminution of the fibrin, the albumen and the red globules of the blood, while the water is augmented in quantity. The face is discolored, and acquires a tint analogous to that of yellow wax. The veins of the skin are no longer to be perceived, even in those

parts where they are largest and most numerous, the pulse is frequent, and palpitations of the heart and extreme prostration occur.

172. An excessive amount of sunlight, on the other hand, is not only injurious in certain diseased conditions, but is also capable of producing disordered action in persons who are in a good state of health. Persons much exposed to strong reflection of the sun's rays from the sand or snow are very liable to ophthalmia or to snow-blindness.

173. Sunlight in convalescence from almost all diseases acts, unless too intense or too long-continued, as a useful stimulant, both to the nervous and physical systems. Experience has shown that health is promoted by giving the sunlight a fair opportunity to penetrate into every nook and corner into which it can make its way. In dwellings it is desirable to give as many as possible of the living and sleeping rooms the benefit of abundant sunlight. This is usually secured by giving them a southern aspect. Broad verandahs, heavy vines trailed upon trellises, and overhanging shade trees, are very attractive and beautiful, and are often comfortable during the heat of summer, but, in so far as they exclude the sunlight and render dwellings damp, they are bad.

174. The cellar is another very important part of the dwelling. In addition to being well drained, clean, dry and well ventilated, it should be well lighted. In many instances cellars are allowed to become the very reverse—damp, mouldy vaults.

175. According to the degree of humidity, climates are divided into moist and dry. The relative humidity of the air is determined by the difference in temperature indicated by the wet and dry bulb thermometers. (Sec. 157.) This important constituent of climate appears under the forms of rain, vapor, fog and dew. Professor Tyndal's observations have shown how greatly the humidity of the air influences climate, by hindering the passage of heat from the earth. The chief effect of moist air is that which it has on the evaporation from the skin and lungs, and therefore the degree of dryness or moisture of an atmosphere should be expressed in terms of the relative humidity taken in connection with the temperature and movement of the air, and its density if this latter varies much from that of the sea-level.

176. The evaporating power of an atmosphere which contains 75 per cent. of saturation is very different, according as the temperature of

the air is 40° or 80° Fahrenheit. As the temperature rises, the evaporative power increases faster than the rise in the thermometer. Between 70 and 80 per cent. is considered by the majority of writers on this subject to be the most agreeable amount of humidity for healthy people. The evaporation from the lungs produced by a dry atmosphere would seem to have an irritating tendency. From the experiments of Lehman on pigeons and rabbits, it would appear that more carbon dioxide is exhaled from the lungs in a moist than in a dry atmosphere. Warmth and humidity are borne more easily than cold and humidity.

177. **The spread of diseases** is intimately related to humidity. Malarial diseases rarely attain their greatest extent until humidity approaches to saturation. Plague and small-pox are both checked by a dry atmosphere. In the dry wind of West Africa small-pox cannot be inoculated, and vaccination is very difficult in dry seasons in India.

178. **The unhealthiness of the West Coast of Africa** is to be ascribed not so much to the elevated temperature as to the humidity, to the want of cultivation of the soil, and to the rank vegetation which, decaying, spreads abroad its death-dealing exhalations. In some parts of Asia we find the same causes in operation, but, perhaps, not to so great an extent, as the soil there is more under cultivation, and there are also high mountain lands in the interior, such as the Neilgherry or Himalaya Mountains, in which Europeans can recover their health and strength without incurring the great expense of a journey to Europe. Diseases peculiar to unhealthy portions of hot climates are chiefly malarial, modified in intensity and character by local circumstances.

179. **This malaria** is one of the most important subjects to be considered in the question of climate. Two theories relative to its nature claim attention. The oldest, promulgated by Lancisi in 1695, is to the effect that malaria is constituted of gaseous emanations from the decomposition of vegetable matter through the action of heat and moisture. The more recent theory ascribes malaria to the presence of minute microscopic germs in the atmosphere—sufficiently minute to be wafted about by the motion of the air—acting upon the organism through the medium of the lungs. Few subjects connected with Hygiene are of greater importance and interest.

180. Some of the laws by which malaria is governed are well established by observation. 1. It is most potent at its place of origin. 2. More noxious during the night than during the day. 3. Its greatest activity is at the rising or setting of the sun. 4. It is capable of being moved by winds from the places where it is formed to others which in themselves are healthy. 5. It exhibits a great affinity for water. A situation even to leeward of a focus of malaria will suffer comparatively little from fever if a sheet of water intervenes. Drinking the water of marshes sometimes produces fever. 6. Malaria has an attraction for trees and other forms of vegetation; therefore, the planting of trees or shrubbery in the immediate vicinity between the originating point of malaria and the place to be protected will, in a great measure, prevent its access. 7. The first turning up of the soil leads to malaria, but continued cultivation causes it to diminish in violence. 8. It is prevented, in a great measure, from exercising its deleterious influences, by fires. 9. Small daily quantities of quinine also act as a preventive.

181. Dwellings and school-houses should be built as far as possible from all sources of malaria, such as stagnant water, mill-ponds, ditches, etc. Low situations should be avoided, and the floor should be raised from the ground. To prevent soil-air from ascending, the spaces intended for buildings should, after drainage, be covered with, first a layer of charcoal and then one of good concrete of sufficient thickness and durability. Sites should also be chosen with reference to prevailing winds, so as to be to windward of all sources of malaria. If the neighborhood is one abounding in these, such as mill-ponds and undrained lands, it would be well for the school-house to be so placed as to have an intervening sheet of water and a row of trees between the water and the building. If there is, in a malarious region where a school-house or dwellings are to be erected, any elevated ground, it should be chosen for the site. Even a few feet may lessen danger, but only at greater heights can complete security be obtained. The elevation of perfect security in different parts of the world is not definitely determined; but it appears to be in Italy 400 to 500 feet; in South America, 3,000 feet; in California, 1,000; in India, 2,000 to 3,000; in the West Indies, 1,400 to 2,200 feet.

182. Soil consists of the layer or crust of earth more or less mixed

with remains of animal and vegetable substances in a state of decomposition.

183. The chemical composition of certain soils has an important bearing on health. Alluvial soils, rich in organic matter, are, comparatively speaking, unhealthy. They aid in the production of malarial and other zymotic diseases. Granitic rocks, whilst they are generally healthy, have been known to produce similar effects when undergoing a process of disintegration. Sands also differ according as they hold organic matter or not. The baneful influences of "made soils" will be fully considered hereafter. The water of lime-stone formations is apt to give rise to goitre and calculus. The water-supply of alluvial soils is often alkaline.

184. The mechanical structure of soils has a very marked influence. Clays and marls are unhealthy, on account of their retention of water. When they underlie alluvial soils they intensify the unwholesome influences of the latter. Marshes are common under such conditions. Whilst a structure of gravels and pure sands is in itself conducive to health, they may have an opposite effect in connection with the "conveniences" of human habitation. Their very structure favors the interchange of the contents of filth-receptacles and wells, and the pollution of the ground-air and ground-water. The germs of typhoid fever travel in a lateral direction in sandy and gravelly soils. These results are still further increased if a substratum of clay or other impenetrable material underlies the sand or gravel. If, on the other hand, such soils have a good slope, and are kept clean, and the drinking water is properly protected, the natural drainage which takes place in them renders them very healthy. This last remark will apply also to hard soils, such as clay-slates, limestone, sandstone, and the purer kinds of chalks.

185. The configuration of the soil, it will be found, has influences no less marked. We can easily see how the circumstances of hill or plain, regular slope, ravines and water-courses, affect the disposal of the ground-water and of the products of human habitation. Hill and plain also produce different results as regards the action of winds, rain and snow; whilst the direction of the slope of a hill will affect its climate. The fruit-grower is well aware of the advantage of a southern slope, especially in the cooler seasons of the year.

186. Spots where the air most stagnates, such as valleys and ravines enclosed by hills, are unhealthy. A ravine running down to a marsh is apt to be a breeding place for malaria, particularly if it is closed at its upper end, the wind being thus prevented from blowing through it.

187. On plains the most dangerous points are at the foot of hills, where the water washing down alluvial soil causes an exuberant vegetation. The next most dangerous spots are depressions below the level of the plain, into which there is drainage. This is especially the case if they are sunk in the gravelly bed of a region overlaid with alluvial soil. The term "punch bowls" is often applied to such depressions.

188. Air in the soil.—The hardest rocks are alone free from air. The greater number even of dense rocks, and all the softer rocks and the loose soils covering them, contain air. The amount in loose sands is often 40 or 50 per cent.; in soft sandstones, 20 to 40 per cent.

The air in soils has been examined, and found to be mostly very rich in carbon dioxide. It is very moist, and generally contains effluvia and organic substances of animal and vegetable origin. Occasionally it contains carburetted hydrogen, and in moist soils, when the water contains sulphates, a little hydrogen sulphide may be found.

189. There is a continual movement in this subterranean atmosphere; the chief causes of it being the diurnal changes of heat in the soil, and the fall of rain, which rapidly displaces the air from the superficial layers, allowing it to re-enter as the water soaks away; and again, by raising the level of the latter, slowly throwing out large quantities of air. Local conditions also influence the movement. A house artificially warmed draws air from the ground below, and even from great depths. Coal gas escaping from pipes, and prevented by the frozen earth from reaching the surface, has been known to pass laterally for some distance into houses. The air of cess-pools and of porous or broken drains will pass into houses in the same manner.

190. Made soils have a very unhealthy influence on persons living in houses built on them. This influence lasts for a long time after the soils are laid down, there being a constant ascent of impure air into the warm houses above. To prevent this is a matter of great import-

ance, and it should be accomplished in the manner indicated in Sec. 181. Even on the purest soils it is desirable to observe the rule of cutting off the subsoil air from ascent into houses.

191. The power of soils to absorb water constitutes another important point in their hygienic relations. Some soils are much more retentive of water than others, and on this account exert a deleterious influence on health. Two circumstances conjoin to influence this hygroscopic property, viz., the porosity of the soil, and the proportion of deliquescent salts which enter into its composition. The following table of the power of different soils to absorb moisture is taken from M. Schübler's experiments :—

KIND OF EARTH. (500 centigrammes of each kind being spread out to absorb moisture.)	CENTIGRAMMES OF MOISTURE ABSORBED.			
	In 12 hours.	In 24 hours.	In 48 hours.	In 72 hours.
Silicious sand	0.0	0.0	0.0	0.0
Gypsum	0.5	0.5	0.5	0.5
Calcareous sand	1.0	1.5	1.5	1.5
Light clay	10.5	13.0	14.0	14.0
Heavy clay	12.5	15.0	17.0	17.5
Calcareous matter in fine powder	13.0	15.5	17.5	17.5
Argillaceous earth	15.0	18.0	20.0	20.5
Pure clay	18.5	21.0	24.0	24.5
Humus or surface soil	40.0	48.5	55.0	60 0

192. Humus, or vegetable mould, is pre-eminently distinguished for its power of absorbing moisture, and it may be well to allude briefly to its distinguishing features. It is a dark, unctuous, friable substance, nearly uniform in its appearance, resulting from the slow decay of vegetable and animal matter—a compound of oxygen, hydrogen, carbon and nitrogen. Good samples of it are garden mould or the mould of old neglected dung-hills. It renders stiff clays porous, and consolidates loose sands. It will be thus seen to be the worst possible soil on which to place school-houses or other buildings intended for habitation, unless the precautions against admission of ground-air and dampness previously alluded to are taken. More particularly is it

highly objectionable if the sub-soil is formed of clay. Rain which enters on such ground, instead of evaporating, soaks through the first stratum and passes into the clay, is absorbed, and causes the surface to remain for a long time damp and unhealthy.

193. Water exists in the soil either as moisture or ground-water. When air as well as water is present in the interstices of soil, it is termed ground moisture. Pettenkofer's description of ground-water is that all the interstices are filled with water, so that, except in so far as its particles are separated by solid portions of soil, there is a continuous sheet of water. This is at very different depths below the surface in different soils, sometimes only two or three feet from the surface, in other cases as many hundreds. This sheet of water is in constant movement. Pettenkofer reckons its rate at fifteen feet daily. Its level is constantly changing. The causes of this change are, rainfall, pressure of water from rivers or seas, and alteration in outfall, either by increased obstruction or the reverse. -heat

194. Marked diminution of sickness by drainage has been noticed in malarial districts, the increased outfall lowering the level of the ground-water. The prevalence of typhoid fever, cholera, and other diseases of a zymotic character, is believed to have an intimate relation with the level of ground-water, especially when after having risen to an unusual height it rapidly falls. Assuming the truth of this connection, the other conditions which Pettenkofer considers necessary to their production are impurities of the soil from animal impregnation, and the entrance of specific germs of the several diseases into the drinking water.

195. Soils differ in their capacity for absorption, retention and radiation of heat and light. The following table shows the capacity for retaining heat:—

Kind of Earth.	Faculty of retaining heat, that of sand being 100.
Calcareous sand	100.0
Silicious sand	95.6
Light clay	76.9
Gypsum	73.2
Heavy clay	71.1
Argillaceous earth	68.4
Pure clay	66.7
Calcareous matter in fine powder	61.8
Humus	49.0

In camping out a sandy soil should, therefore, be selected for the bivouac.

196. The influences of vegetation vary. Herbage is generally beneficial, especially if it be periodically removed by cattle or in the form of crops. Cultivation and drainage are useful in this way, the improvement of malarial regions often being very marked, especially after the baneful effects of first breaking the soil have passed away. The cultivation of rice fields by irrigation and flooding is, of course, an exception to this rule.

Brushwood is not generally found to have a healthy influence. It does not allow of the free action of the sun and rain, and the dead leaves slowly decay, and give off unwholesome exhalations. In marshy land, however, it also tends to intercept the malarious exhalations, and should not be disturbed. The late Dr. Parkes paid much attention to this subject in connection with military camps. He advises, that in those cases where the camp is only a temporary one, the brushwood be not removed; but if the camp is to remain in the neighborhood for a long time, and the brushwood is not doing service as a screen against marsh exhalations, then it should be removed. This removal should be made when the sun is high, and not in the early morning nor in the evening. It might also be added, that it is less harmful to disturb such places in winter or summer than in the spring or autumn.

Trees are generally useful in rendering the moisture in the air and soil more equable. They also convert large quantities of carbon dioxide into oxygen. They act as shelters from bleak and unwholesome winds; sometimes, on the contrary, they prevent the passing away of the latter by free perflation. Their influence is similarly variable in shading us from fierce heats on the one hand, and shutting us out from the benign influence of the sun on the other hand. Hence their removal or detention must be determined upon after a careful and judicious consideration of all the circumstances in each individual case.

197. Winds have a very great influence on health. Through the action of the almost constant currents which are excited by the varying density of the atmosphere, the air which has become contaminated with organic and other exhalations is removed, to make way for that

which is fresh and contains the normal amount of oxygen. On the other hand, winds often serve to transport malarious emanations and specific germs of disease to great distances. Epidemics of small-pox and other infectious diseases have been traced to the burning of contaminated clothing in the open air, instead of in stoves or furnaces, as also to dissemination by the wind of the dried pustules and scales of the different contagious diseases from the hanging of infected clothing to dry after washing, the temperature of the water not having been sufficiently high for the destruction of infective germs.

198. **The direction from which a wind blows modifies** its character. An east wind generally brings moisture with it, and is, therefore, liable to induce catarrhs and rheumatism. South winds are often hot, dry and enervating. North winds occasion a great reduction in temperature. In Switzerland it is held that a north wind very speedily drives away influenza. In Italy, and along the north shore of the Mediterranean, a very relaxing wind from the south-east, called the Sirocco, prevails in the early spring. The north-west wind, or much-dreaded Mistral, is occasionally experienced with great severity in some places on the north shore of the Mediterranean, especially at Cannes, Hyères and Nice. The north-east wind, or Bise, coming from the Arctic regions, is very cold and dry, its moisture being lost as it blows over the Alpine mountains. The Simoom is a noxious wind of the deserts of Africa and Asia, not periodical, and lasting but a short time. Animals of all kinds instinctively flee for shelter at its approach, or crouch to the earth until it has passed over. This wind carries with it a fine sand, and is irrespirable. Its deleterious effect is presumed by some to be increased by the presence of sulphurous acid.

199. **Electricity** is another factor in climate. By some it is considered that up to the present time we are ignorant of the part played by this agent either in the preservation of health or production of disease; by others, that the importance of atmospheric electricity as a curative power in disease is not to be measured by the little we know about the agent itself; that electric tension in the atmosphere is, as a rule, increased with each decided elevation above the sea level, and that the increased electrical influence of the atmosphere of high altitudes is one of our most important aids in the battle against consumption.

200. Ozone, a constituent of the air, alluded to in Sec. 47, is formed during thunder storms by the electric fluid passing through the atmosphere. It was supposed by Professor Schönbein—its discoverer—to exert a powerful influence on health; to be destructive of malaria; and also that cholera was in some manner connected with it, as during epidemics of that disease there was found to be a minimum amount present in the atmosphere. No sufficient evidence on this subject has as yet been adduced. It is most abundant in sea air and that of high levels; also on foggy days, during the prevalence of west winds, and in the winter season; more so in the country than in populous places, and at night than in the daytime, being especially abundant about daybreak. Some observers say that it has an irritating action upon the air passages.

201. In high altitudes the pressure of the air is lessened, evaporation is more rapid, and the vapor is less perceptible. The clearness of the air is also rendered greater by the increased facility with which radiant heat is transmitted in such climates. At elevations varying from 5,000 feet upwards, as at Davos Platz, in the Upper Engadine valley, and at Denver City, Colorado, radiation is rapid, and very soon after sunrise the temperature rises, because of the very slight resistance which the rarified and dry air offers to the sun's rays, while after sunset the terrestrial radiation is also rapid, because there is no moist envelope shrouding the face of the earth. Comparing the effects inimical to life in mines, cellars and ill-lighted abodes, with the benefit of sunlight at low levels, where a stratum of moisture intercepts the sun's rays like a thin cloud, and then with the healthful influences of the unobstructed sunshine of high lands, it may be said that the beneficial effects of sunshine increase with increasing altitude.

202. That cool, dry climates and high altitudes are far better for consumptives than warm, moist ones at the "sea-side," or on tropical lowlands, the experience of Dr. T. C. Williams would seem to establish. In his Lettsonian Lectures we find an analysis of 593 weeks spent by 251 consumptive patients in foreign climates. Dr. W. says: "As to what class of patients profit most by dry climates, it has been shown that, taking collectively all forms and degrees of phthisis, the dry climates are the most likely to arrest the disease." As to the desirability of moist climates for consumptive patients, the evidence is

decidedly against their use in the treatment of ordinary chronic phthisis. The addition of warmth only makes the damp tell more unfavorably, though a strong saline element and invigorating breezes do something to counteract the humid influence. Still, even these do not make a moist climate compare favorably with a dry one.

203. The health resorts of Canada are sufficiently known to render any lengthened remarks unnecessary: whether on the salt water of the Lower Provinces, or in the lake districts of Muskoka and Central Ontario, or on the shores of the Georgian Bay or of the Great Lakes, they are invaluable as summer resorts on account of their invigorating influences. Of the other marine climate in our Dominion to be opened up by the Canada Pacific Railway, viz., Vancouver's Island and the adjacent coast, including the lower Fraser River, it may be said that it is never very cold in winter nor very warm in summer; the nights are cool. Some winters pass without snow and with very little frost, but with a good deal of rain. From June to October the air is warm and genial. During these months, as a rule, little or no rain falls, the rainy season being from November to March. From the great rainfall during this period the atmosphere is heavily charged with moisture. The thermometer rarely falls below freezing point, but there are frequent cold and variable winds.

204. As British Columbia has different altitudes so it has different climates. In the interior of the mainland there are ranges of mountains varying in height from three to four thousand feet, and many, still higher, covered at the tops with perpetual snow; sloping inwards from these lofty mountains lies the lofty plateau of mainland of British Columbia. The climate of this mainland, resembling that of the interior of Canada, is very warm in summer and very cold in winter. The winters, although cold, are very sunshiny, and the atmosphere clear and bright. Therefore, either on these lofty ranges on the mainland, or on the foot-hills of the Rocky Mountains beyond Calgary, would invalids from lung diseases be more likely to be benefitted than on any part of Vancouver's Island. It is very probable that before long excellent health resorts may be established on the line of the Canada Pacific Railway.

CHAPTER VIII.

NATURE OF REFUSE SUBSTANCES—EFFECTS WHICH THEY MAY PRODUCE—DESIDERATA IN THEIR REMOVAL—VIOLATIONS OF THESE.

205. We will consider this subject under the following heads :—

I. The nature of the substances of which the refuse of households and of communities consists, and the effects which these may produce on the surrounding air and water.

II. The desiderata to be kept in view in the disposal of them, and some of the ways in which these desiderata are commonly violated.

III. The various methods by which they may best be carried out, and the principles to be observed in connection with these methods.

IV. The ultimate disposal of sewage after removal.

I. **206. The following substances are comprised** in the refuse of households :—

(*a*) Ashes, dust, waste paper, and other dry refuse, not liable to become prejudicial to health by speedy decomposition.

(*b*) Kitchen slops and vegetable and animal refuse,—garbage.

(*c*) Bedroom slops.

(*d*) Excrementitious products not included in the last division.

207. The last named of these four divisions of refuse is that which bears the most constant relation to population, both in amount, character and effects. A slight calculation will show us how much more important it is than people generally suppose that there should be proper and systematic methods for the disposal of sewage.

208. By a computation based on the observations of physiologists it will be found that the solid product of 500 people, in a mixed population, is equal to 14 tons each year, according to Parkes, or 18 tons if we take Frankland's figures; and the liquid to 7,323 cubic feet. In a thickly settled portion of one of the cities of this province, eighty-

five houses have been counted in a block 67 yards wide and 200 yards long. Assigning an average of six inmates to each of these houses, we would have a population of a little over 500. In other words, on a space of 67 yards by 200, in a region thickly studded with houses, we have stored at the close of each year an additional mass of from 14 to 18 tons of solid excreta, and enough liquid to fill a tank the dimensions of which are 20 feet each way; or passing to the purer atmosphere of a country village of 2,000 inhabitants, we would have produced 57 tons of solid, and over 29,000 cubic feet of liquid excreta.

210. The total amount of filth of communities may be better estimated than it usually is, if it is borne in mind that the excreta of human habitations, great as it is in amount, is considered by sanitarians to form but a small proportion of the whole.

211. Among the effects produced the pollution of the air may first be noticed. The three classes of substances last mentioned in our enumeration pollute the air directly by the emanations arising from them. During decomposition they evolve large quantities of gases.

212. Myriads of low organisms are also given off, and amongst them, germs of disease. Many of our most common zymotic diseases, such as typhoid fever and diphtheria, are propagated and spread in this way. Disease germs may be given off even before decomposition occurs. These gases and germs may be taken into the system, and act directly on the human organism, producing diseases of a definite nature; or they may rob the air of so much of its oxygen, by combining with it, that they lessen its power of restoring the blood and tissues to a healthy condition, and thus cause a general deterioration.

2 **213. The soil,** too, becomes filth-saturated, and the ground air, being constantly drawn into and expelled from its interstices, passes out, laden also with germs and impurities.

3 **214. The filth carried into wells** from the surface and through the soil is the cause of a large amount of the typhoid fever, diphtheria, and other zymotic diseases which occur amongst us.

II. **215. The points to be aimed at in the disposal of sewage are :—**

(*a*) To remove all the waste products of households that are liable to become injurious to health by giving off gases or disease germs.

(*b*) To remove them *completely*.

(*c*) To remove them *before they can decompose.*

(*d*) To remove them to a place where they cannot by their subsequent presence do harm.

(*e*) In their method of removal to take care that the gases which they produce are not allowed to accumulate. In our water-carriage system this will require a free ventilation through sewers, drains, soil-pipes and waste-pipes.

(*f*) That in this last named system means be provided to direct the necessary escape of the gaseous contents of sewers to points where they cannot come in contact with human beings, and to prevent all escape at points where they would come so in contact.

216. A consideration of the many ways in which these principles are violated, and a few illustrations, may aid us in acquiring a due appreciation of the importance of them, and of their practical application

For violation of the first we have not far to seek. We have already pointed out that in the large majority of our back yards not only are the refuse of kitchens and slop-water thrown upon the ground, but decomposing masses of the most offensive filth are stored year after year in pits dug in it, with the results described above. This too prevalent system is a disgrace to the civilization of the nineteenth century. The effects on health are bad at all times; but in times of epidemics they are liable to become extremely so. A fruitful condition for the rapid spread of any epidemic is thus provided.

217. That removal should be complete is the second principle laid down.

Incomplete removal or non-removal of sewage matter frequently arises from drains becoming leaky or choked. Sometimes no sufficient attention is paid to securing a good foundation for the drain, and it assumes a zig-zag outline, the pipes running alternately up and down. The connections become broken or opened out, whilst at the same time the sewage lodges in the depressions, and we have extensive soil pollution.

Connections are often left open, too, because the workmen have not taken the trouble to secure concentricity of the pipes, and to properly fill the joints with suitable material. Sometimes a small tile is entered into a large one without any tapering reducing pipe, the large opening between the two being filled with cement or blue clay, through which rats work their way, leaving openings into the drain.

Brick house-drains—which should never be used now—are often opened by rats, and discharge sewage into the soil.

Cases are known in which sinks have been put into houses, the ends of the waste-pipes carried through the floor, and no attempt made to connect them with drains. As an example on a large scale of similar neglect, we may refer to the Toronto Asylum for the Insane in days gone by. An unusual amount of sickness prevailing in that institution some thirty years ago, led to an examination of the drains. On taking up the floors, an immense amount of sewage was found, and it was discovered that the contractor who laid the inside drain and the contractor who laid the outside one had failed to arrive at such an understanding as would lead to a connection being made; several feet of earth had been left between the two drains, and the sewage of years had accumulated under the floors.

In all cases of soil pollution or surface pollution under houses, or in their immediate vicinity, we have to bear in mind that the heated air in them creates a constant "ascensional" current, drawing and carrying with it impurities originating below.

218. Delay in removal till decomposition occurs results from many of the causes already mentioned; also from drains having too little fall, being insufficienty flushed, or having junctions improperly made and allowing of deposit. Even though the sewage be completely removed after a time, yet the delay in removal gives rise to a generation of foul gases, with the results before described.

219. That there should be a suitable outfall or proper place of deposit is our fourth requisite. Where sewers are used, they should not pour forth their contents in places so situated that offensive and injurious contamination of the air or drinking water of populous districts must result; and, furthermore, no decaying, decomposable or offensive materials of any kind should be deposited in situations where they may do harm.

In some towns in this Province (as elsewhere) epidemics of typhoid fever have been traced to improper outfall of sewage. In one instance the water supply was affected thereby; in another, a small creek flowing slowly through the town is transformed into an open sewer. In another, a prolonged discussion took place as to whether water-closets should be connected with the town sewer. The

question was wisely decided in the negative, on account of the want of proper outfall, and for other reasons.

220. Scores of "eligible building sites" are made up of the remains of cats and dogs, the emptyings of straw ticks, kitchen refuse, and other decomposing animal and vegetable matter. When the grass has covered the surface of these lots they are as pretty to look at as any others. Provided the houses erected over them are placed on posts, and a free circulation of air underneath the floors is secured, harm may not result; but it can be readily understood that if the walls are sunk into such material, the constant up-draught of the heated air of the house will draw up the gases and low organisms which abound in such a soil. The visitation of that memorable epidemic of yellow fever which took place in Memphis a few years ago, was partially attributable to the deposit of garbage in the city.

221. Owing to the absence of proper ventilation of sewers, noxious gases and germs of disease accumulate, and do much harm. It is found that with an ill-ventilated system of sewerage the higher, and once more healthy, districts of a city often become the more pestilential, especially if the sewers are large and the flow sluggish. It is claimed by some that in the small glazed-tile sewers of the separate system (see Sec. 252) no decomposition occurs: in this case the gases themselves will not be as injurious in a general way as they otherwise would be; but they may bear in them the germs of diseases such as typhoid fever, cholera, scarlet-fever, small-pox, etc.

222. That they cannot be perceived by the sense of smell is no conclusive proof of the absence of sewer gases. Some injurious gases reveal themselves unpleasantly to the nose, while others do not. These last are so insidious in their nature as to be doubly dangerous. As examples, the baneful results which ensue from living in houses under which water lodges and becomes stagnant may be referred to. There are few medical practitioners who have not witnessed these results. The miasmatic poison of ague is similarly inodorous, or has no necessarily unpleasant odor. In like manner sewers have sometimes very little unpleasant smell. In some cases we have a smell somewhat similar to that produced by those burning fluids into the composition of which fusel-oil enters. People living in a house become so accustomed to these faint odors as to take little notice of them

and with some people the sense of smell is not very acute. Hence we must be very careful how we accept negative evidence as to the presence of noxious gases. And hence, too, we must be all the more careful to avoid their existence and presence, and to devise means to this end.

223. Among the gases more commonly evolved from sewers may be mentioned sulphuretted hydrogen, carbonic acid, carburetted hydrogen, nitrogen and ammonia. Many cases of asphyxiation in sewers and cess-pits are on record: no less than eight deaths from this cause have occurred in the sewers of Chicago within the past year.

224. The causes operating in the evolution of sewer gas, besides those acting more generally, such as the natural *diffusion of gases*, are :—

1. *Difference of temperature* between sewer and external air, causing a rapid interchange in accordance with the laws which regulate the movements of unequal weights of air.

2. *Upward draught* in houses acting as a ventilating shaft, in the wake of which the sewer air will follow if allowed.

3. The *expansion force* created by the sudden accession of heat in the drain, viz., by pouring down hot soap-suds or boiling water. As the air expands the pressure is increased. If, then, the temperature of the air in the drain be raised from 50° to 150°, the result will be a pressure of $6\frac{7}{10}$ feet head of water, enough, it will be seen, to force any trap, unless some other means are provided for its escape. And this rise of temperature is not at all an improbable one.

4. The *flow* of water into the drain causes an expulsive force. When water is poured into a drain it must, of course, displace its own bulk of air (less the small amount gained by compression), for two bodies cannot occupy the same space at the same time. Out of which end of the drain (supposing that it has no ventilator) this air shall pass will be determined by circumstances; it passes most readily where it meets with least resistance, always giving preference to an upward direction, owing to the greater gravity of the water. Storm water suddenly filling the sewers acts powerfully in this way. This ebb and flow operate like a double-acting piston or syringe. Partial choking of the drain gives rise to confined air constantly increasing, expanding and being displaced.

5. The rise and fall of sewage in the drain also cause an increased generation of gas by the constant *evaporation* arising from the alternate wetting and drying.

6. The wind blowing up the sewers will force the sewer-gas backwards. Some engineers have proposed flap gates at the mouths of sewers. But it is better to let the fresh air blow up, and make sufficient vents for it to sweep through and purify the sewers.

225. We find sewer gases disposed of in various ways :—

In a very large number of cases they escape into dwellings.

In some instances they are supposed to discharge through gratings in the centre of the road, but in many cases they discharge at the edge of the sidewalk through untrapped gullies, or through gullies the traps of which have been emptied by evaporation or leakage.

The errors which are most frequently coming under notice as detrimental to health are those which allow of the

226. Entrance of sewer gases into houses.—It has been well remarked that "unventilated sewers are more dangerous than steam boilers without safety valves."

In one of the towns in which there was a violent outbreak of typhoid fever, calling for investigation by the Provincial Board of Health, box-drains were found, without any trap or vent, bringing up the gases from a larger box-drain with a broken bottom, which contained portions of the contents of cess-pools which flowed into it. Some mechanical impediment to the return of sewer-gas, technically known as a "trap," should be placed as near as possible to the commencement of every waste-pipe. Various forms of these will be described hereafter, as also the best means to be taken to prevent their becoming useless.

Sewer-gas often escapes into houses through bad connections and joints in the inside plumbing, or from corrosion of pipes, or from imperfections in connection with traps. (See secs. 253–261.)

227. The ventilating of the sewers at the level of the road-bed, bringing gases and germs up at the feet of wayfarers, and opposite doors, windows and air-ducts, is also a violation of the sixth point laid down. In a report by Mr. Sedgwick Saunders, published some time ago in *The Lancet*, he attributes to sewer-gas, arising from ventilators in the road-bed in some of the narrow streets of London, cases of typhoid

fever and sore throats, and "suggests an abatement of the evil by the closing of the street ventilating-gratings entirely and the erection of upright shafts, six inches in diameter, to be carried above the roofs of the adjacent houses." I am sure that it has occurred to many of us to notice the disagreeable odors that sometimes arise from the street gratings or from the unsealed traps of gullies. Sometimes, too, we are more than usually impressed with the reality of the exhalation of sewer-gas by the sight of columns of vapor arising from these gratings and gullies, and rendered more visible by the condition of the atmosphere on a cold, damp day; but we should bear in mind that gases and germs often proceed from sewers even when they are not apparent to sight or smell.

Some speak of the placing of charcoal-trays in the ventilators as a sufficient safeguard. Even were the charcoal constantly dry, sewer-gas at times makes its exit too rapidly for the charcoal to exert any action upon it. So that, however useful an adjunct charcoal may be, it cannot be considered a preventive to the injurious effects of sewer-gas.

Besides, ventilating by gratings in the road-bed is not to be relied on in winter: they become clogged or closed by ice and frozen mud.

228. In some cases the sewer-gas is discharged above the house-tops. Proper consideration will show that this is the correct method. It is surely safer to discharge it away above our heads than at our feet. This method is illustrated in the diagram on page 107.

229. The drinking water of houses is often polluted by the water-closets and urinals of a house being supplied directly from the same system of pipes in which it is carried. Sometimes the pressure is taken off the pipes, and they become emptied of water and draw in air from the closets. This air may be foul or contain germs of disease, and it may become mixed with the drinking water and produce disastrous results. Instances of this are cited in the reports of the Local Government Board of Great Britain. In Caius College, Cambridge, a severe epidemic of typhoid fever was caused in this way, although the air had been drawn in only once or twice. Absorption of sewer gas by tanks containing drinking water has repeatedly given rise to trouble. Closets and urinals should always have their own separate tanks, and the water from these should never be used for drinking purposes, nor for washing milk pans and other similar utensils.

CHAPTER IX.

SYSTEMS OF SEWAGE DISPOSAL—DRY METHODS—WATER-CARRIAGE SYSTEM—PNEUMATIC METHODS—ULTIMATE DISPOSAL AND UTILIZATION.

III. 230. **We may divide the methods for the disposal of sewage in** accordance with sanitary principles under two principal headings—"Dry Systems of Removal" and the "Water-carriage System," or, as they are often called, the dry and wet methods. We may also give a passing notice to certain Pneumatic Systems.

Attention will first be directed to the best methods of disposal in those cases where the water-carriage system cannot with advantage be adopted.

231. In the dry systems the liquid refuse is kept separate from the solid, and the two are disposed of in different ways. It is a matter of common observation that solid organic matter, if kept comparatively dry, is not subject to offensive putrefaction, while the reverse is the case when there is a certain quantity of water present; a practical attention to this fact in dry systems of disposal will obviate those putrefying masses which now form such offensive abominations in our midst.

The subject naturally divides itself, then, into two portions, which require separate consideration, viz.: the disposal of (*a*) solid refuse, and (*b*) liquid refuse.

232. Of the various methods for the disposal of solid excrement there are three which seem to have met with a fair degree of success. These are (1) the Hull Ash-closet system; (2) the Dry Earth system; (3) the Rochdale Pail system.

233. In the Hull Ash-closet (Fig. 25), the back, ends and floor of the receptacle under the seat are built of brick, laid in cement. The front is a movable wooden piece, and the seat may be hinged. The floor is

not sunk below the ground level, but slopes slightly from front to back. The whole is properly roofed in and ventilated. In the same receptacle are also deposited all the ashes, dust, waste paper and solid kitchen refuse. All kinds of slops are rigidly excluded. When it is considered desirable to screen coal ashes, they may be screened into the closet after raising the hinged seat.

234. In Manchester a modification of this system exists, the floor being made level and a pail being used, with ashes, as in the Hull closet. In some instances a fixed cinder sifter is arranged at the side, which directs the ashes into the pail and allows the cinders to fall into a box.

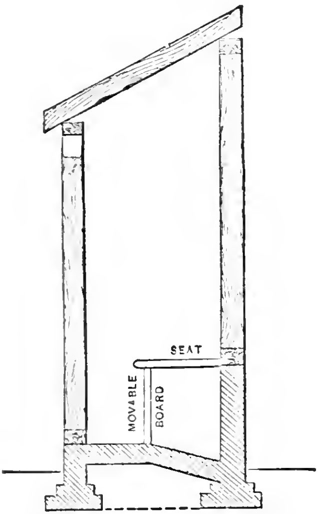


Fig. 25.—Sectional view of Hull Ash-closet, intended to receive all the dry refuse of the household in addition to the excrement.

235. A modified form of the dry-ash closet has been used successfully in some parts of the United States and Canada. In it two pails are used—one under the seat and the other in some convenient position for the ashes. Each time the closet is used a quantity of ashes is thrown in with a scoop.

The above are all out-door closets.

236. The Dry-Earth system is substantially the same as the dry-ash system above described, earth being substituted for ashes. The earths best adapted for the purpose are moulds and loams. Pure sand possesses little or no deodorizing power, while pure clay is difficult to bring into the proper powdery condition, and has a tendency to absorb too much water.

It is not necessary that the earth should be absolutely dry, spreading it out in a dry, sunny atmosphere being sufficient. For use it must be free from lumps and in a powdery condition. This is best effected by screening it. After being used it may be placed in a barrel, where it will undergo a slight heating and fermentation. It is quite inoffensive so long as it is kept dry, and it may be stored for any length of time. It is a valuable manure.

237. **House-closets on the dry-earth system** are very satisfactory if properly made. They are usually constructed with some patent device for throwing the earth down each time the closet is used. One of the principal objects of their inventor, the Rev. Henry Moule, was to find a substitute for the water-closet in dwellings, factories, schools, etc. With dry earth the soap box or barrel, with a scoop, may be used, as in the case of the ash system, and will answer the purpose in households composed of adults, but for children and for mixed communities some one of the automatic earth closets should be employed. The quantity of earth required is estimated at about a cubic foot per month for each person.

The executive difficulties in applying the system are not great, but should be fairly looked at by municipal bodies before introducing it.

238. **The Rochdale pail system** differs from the dry ash-pail method before described principally in the fact that no absorbents are used. The pails are frequently removed, being fitted with tight covers, and clean pails are left in their places. The removal of dry refuse, ashes, etc., forms a part of the system. All the refuse is brought to a depot, where the ashes are spread out on the floor to a certain depth. The contents of the pails are emptied into trenches formed in the ashes, and treated with a small quantity of dilute sulphuric acid; the whole is then thoroughly mixed, becomes, after a few weeks, quite inodorous, and forms a valuable manure. The removal and subsequent treatment has, of course, to be carried out by the municipal authorities.

Whatever system may be adopted, the old privy-pits should be thoroughly cleaned out and filled with fresh earth.

239. **In many country towns and villages** there is sufficient garden space to enable the resulting product to be utilized; wherever this is not the case the removal and disposal should be undertaken by the municipal authorities, and in all cases an efficient system of inspection should be carried out.

240. **Making practical application to school premises** of what has been said, it ought hardly to be necessary to comment upon the simplicity of the above methods, and the ease with which they may be substituted for the old privy-pits, nor to make any remarks as to their superiority over those filthy and disgusting excavations. The in-

fluence of these in the spread of typhoid fever and such diseases is pointed out in other chapters.

In any of the above methods slops must on no account be mixed with the contents of the receptacles.

241. Wherever practicable a system of pipe sewers should be devised for the purpose of disposing of these, and should be connected with the house yards by properly arranged sinks and traps. Since the volume of this concentrated sewage will in general be small, the pipes should be smaller and laid with steeper gradients than those used in connection with the water-carriage system. They should also be provided at intervals with flushing pipes, rising to the street surface, so as to admit of periodical flushing by means of a hose to be connected with street watering-carts. Lamp-holes and man-holes, for the proper examination and removal of obstructions, and ventilating shafts should also be constructed at proper points. Any urinals on the premises should be connected with the sewer, and not with the closet.

242. In treating of the water-carriage system in this work it is not intended to deal with all the questions which would need to be considered in connection with a proper system of sewerage. Many such details would only be of interest to the sanitary engineer or to other persons making a special study of the subject.

243. Certain preliminary considerations, therefore, will only be briefly alluded to:—

1. The *Area* of the locality will have to be estimated by the sanitary engineer in order to provide sufficient sewage accommodation, and yet not so much as to impair the flushing operation of surface water by too extensive a distribution.

2. The *Rainfall* will have to be considered with a similar object in view, and in addition, whether the fall is equable or varying.

3. The *Geological and Physical* characters of the soil have a bearing on the amount of storm-water to be carried by drains; and also upon the question of the care that must be exercised in building them, shifting of drains and soakage of sewage being much more liable to occur in porous than in clay soil.

4. The bearing of *Water Supply* on the flushing and cleansing of sewers will be apparent.

5. The nature of the *present sanitary appliances* must be considered

6. The necessity for deciding whether there are *proper facilities for outfall* has already been referred to. Its importance before commencing or allowing the construction of sewers cannot be too strongly insisted upon.

244. **The materials** of which drains may be constructed:—

Tiles answer well up to a diameter of 18 inches. They must be glazed, to prevent soakage. It will be necessary to see that they are not too porous, that they are strong, tough and true-fitting. Their porosity may be tested by weighing them when thoroughly kiln-dried and again when soaked in water, and noting the difference in weight.

Fig. 26.
Pipe defective in contour.

Their strength is generally tested by putting them under a weighted lever, arranged like the arm which carries the weight of a safety valve, or by dropping weights on to them. They should be true-fitting, for any defect in contour will affect the formation of the joints, and give rise to leakage, as illustrated at *a* in Fig. 26.

Iron pipes should be made use of when pipes of a larger diameter are required. Their brittleness should be tested as in the case of tiles. If drain pipes are not able to withstand the shock of falling earth or workmen jumping down upon them, without cracking, they will allow leakage and sewage pollution of the soil.

Brick must be the chief material for large drains and sewers. The bricks should be very hard and impenetrable, especially for the bottom, to withstand the grinding and polishing action of the passing solid contents. Their porosity and strength may be tested as with tiles.

Concrete has been used, but not very extensively nor with much success.

And lastly we come to the more primitive material, *wood*, either in the form of the box-drain, or, less frequently, as fashioned by the cooper's art.

The too common practice of using wooden box-drains must be condemned. They allow sewage to soak out, they soon break down, and they permit of deposit and choking, especially when laid on the flat, as they commonly are. For a permanent drain, glazed tile pipes (with impervious joints) should be used; or, inside of houses, cast-iron pipes, which when hot have been dipped in pitch. The joints of these should be filled with lead and caulked. These inside drains should, when possi-

ble, be left exposed to view. In some cities this object is carried out, even in the horizontal position, by fastening them along the basement walls. Any leakage is in this way made visible, and can at once be remedied. This precaution should be observed in regard to all inside plumbing.

245. The shape of drains is a very important consideration, and must vary, according as the flow is expected to be equable or variable. If the flow is equable the circular form (Fig. 27) is preferable, because it gives the greatest capacity with the least expense of wall. If it is variable the ovate (Fig. 28) gives the advantage of the deep, narrow stream, when the quantity of fluid is small. So important is the shape of drains, that on it is founded the division into the *deposit sewers* of the olden time, and *self-cleansing* sewers. In old times sewers had to be cleaned out by scavengers, with the same regularity as chimney-sweeping. This was due to the fact that the bottoms were broad and flat, and the slow, sluggish stream was not sufficient to carry off the solid matters which settled as deposits; and deposits once commenced increase by their own impeding action. The same plan is still followed with box-drains. In cases where they are put in temporarily to avoid expense, they ought to be set, not flat, as in Fig. 29, but angle down, as in Fig. 30, so as to allow as little surface as possible for accumulation of deposit, and to give the fluid its greatest possible depth and force.

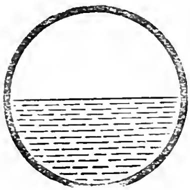


Fig. 27.

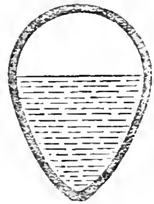


Fig. 28.

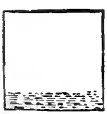


Fig. 29.

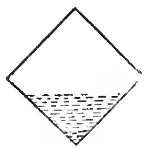


Fig. 30.

246. The foundation or bed of a drain should be firm and solid, so as not to permit of any breaking or disjointing. If pipes are used, small excavations should be made to receive the shoulders, so that these shall not have to bear the whole weight of pipe, contents and superincumbent earth, with no support to the rest of the pipe, which is then liable to break or crack. Provision should be made for carrying away subsoil water, which is liable to make for the new earth formed in digging the bed of the drain. If the drain lie *in a* porous stratum and *over-*

an impenetrable one, the chances of the water running along its course will be especially great. Some tiles are made with a subsoil space, porous or perforated so as to carry off this water.

247. Joints should be true-fitting, so as to prevent gaps, out of which the cement or clay may fall or be forced. Care should also be taken to prevent the apposed ends from losing their concentricity when laid: if the joints be fitted with puddling clay or other soft material, this will give way under the downward pressure of the small end of the pipe, until this latter rests directly on the receiving collar of the next pipe, leaving no space between them on the under wall, but a large gap on the upper (Fig. 31). This will be especially the case if no spaces have been cut to receive the shoulders. To prevent it the joints should be stuffed with oakum, and then with puddling clay or cement, or if the pipes be of iron, with lead. This will also prevent the intrusion of rootlets of trees, which are apt to insinuate themselves and cause accumulation and choking. Some persons try to kill rootlets by mixing bichloride of mercury in the cement. This is a poor expedient at best.

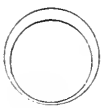


Fig. 31.

248. The junctions of drains, whether they are in a vertical or horizontal plane, should not be at right angles (Fig. 32), as the interruption of the stream and the eddies thus formed will cause deposit, which, when once commenced, will rapidly increase. The tributary stream should be made to enter in a course somewhat parallel to that in the main sewer (Fig. 33).

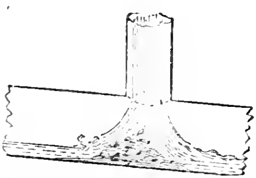


Fig. 32.—Improper Junction.

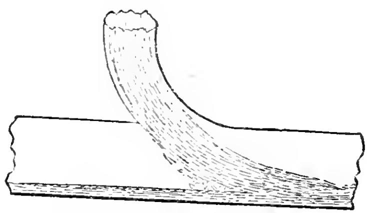


Fig. 33.—Proper Junction.

249. The slope or fall requisite for good drainage will depend on various circumstances: the nature of the matters to be carried off, the volume of fluid, the equableness of flow, the facilities for flushing, and the smoothness of the drain. Solid matters being more likely to lodge

in a shallow than in a full stream, it will be evident that they will be still more apt to lodge if that shallow stream run slowly than if it run rapidly. It is a mistake (and one commonly made) to build drains larger than is necessary for the volume of water to be carried off. A 9 in. drain is often used for a house for which a 6 in. would be ample and would give a better flush.

250. Various experiments have been tried as to the carrying force of sewer streams. According to Latham a velocity of about 180 feet per minute, when running half full, is necessary for efficient house drains. He states that this would necessitate: In a 4-inch drain, a fall of 1 in 92, and would take 7·85 cubic feet per minute; in a 6-inch drain, a fall of 1 in 137, and would take 17·66 cubic feet; and in a 9-inch drain, a fall of 1 in 206, and would take 39·76 cubic feet.

It must be borne in mind that the above calculations as to the necessary slope are based on the presumption of the drain running half full; but such large quantities of water as those indicated above are not generally poured in at once. The main house drain is rarely filled half full, for it is the larger common outlet of a number of smaller drains, and unless these are running simultaneously it will not be half full. Hence the greater necessity for providing means of flushing house drains by causing a body of water to rush swiftly through them, thereby washing out any deposit that may have accumulated.

251. For flushing house drains our first care should be to see that there is provision for nearly filling them, either by the simultaneous action of a number of small inlets, or by one large one. In houses where there is a closet pipe it is generally of nearly half the sectional area of the drain from the house to the street, and by filling it with a good head of water the latter drain will be nearly filled. Many contrivances, differing according to circumstances, will readily suggest themselves for supplying a body of water. The most primitive will be the sudden emptying of a tub of water every day or so.

252. What is called the separate system of sewerage has been introduced into some cities in order the better to attain the complete and speedy removal of sewage. The name of Colonel George Waring, Jr., is intimately associated with this system. The peculiarity of it is that small, glazed-tile sewers are used, only large enough to carry the

sewage, and not allowing of the entrance of storm water. Through these small sewers, with their glazed surfaces, there is a more rapid and complete discharge.

We now proceed to consider the means for the proper dilution and discharge of sewer gases.

253. Traps (See Sec. 226) are of two kinds—"Dry-traps" and "Wet-traps," or "Water-traps." A dry trap is a mechanical contrivance by which some solid body acts like a valve, closing a drain or pipe against the passage backwards of any gaseous or liquid material. A form of dry-trap is here shown: the valve, as seen in fig. 34, has been opened by the flow of sewage, and will close as soon as the flow ceases, as in fig. 35.

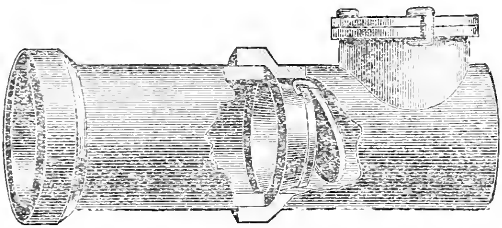


Fig. 34.—Palmer's Trap with the valve open.

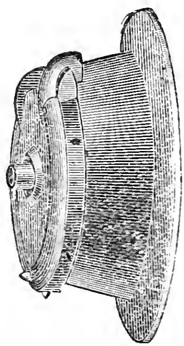


Fig. 35.—Palmer's Trap with the valve closed.

254. Dry-traps are very liable to allow of regurgitation of sewer-gas whilst the sewage is flowing, and also to get so out of order as not to close the drain against a constant reflux. They are, therefore, not so good as water traps properly vented, with frequent change of water and ventilated drains. They should only be used where these conditions cannot be obtained.

255. A wet or water-trap (Figs. 36 and 39) is a contrivance holding, in the course of a drain, a body of water which entirely fills a short section of it, and separates the air below this section from the air above it, the through current of air being completely stopped. No air can pass through the trap except under such pressure as will force

the water in it. In some wet traps mercury seals are used to prevent evaporation.

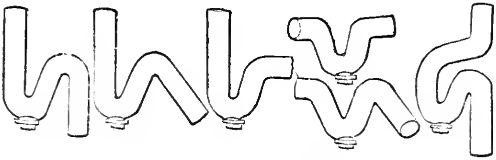


Fig. 36.—Various forms of Traps.

The addition of the dry principle which is made to some wet-traps is, to say the least, useless; it is apt to fail, and tends to accumulate filth. Inside a house no drain should be allowed to exist unless there are proper facilities for a sufficient water-trap vented and furnished with frequent change of water. (See Secs. 257-261.) There, are, however, certain situations out of doors where a water-trap is apt to become dry, and where a combined trap may answer a useful purpose.

256. Guerin's gully trap (Fig. 38), invented by Mr. Thomas Guerin,

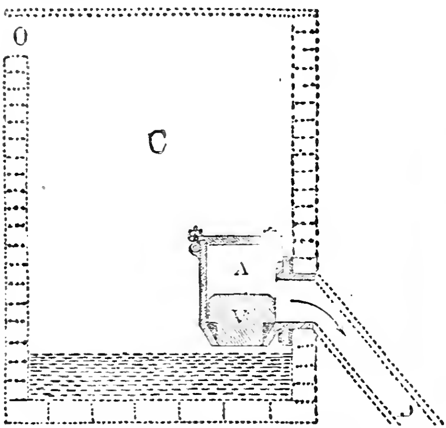


Fig. 37.—Street gully, with Guerin's trap in position.

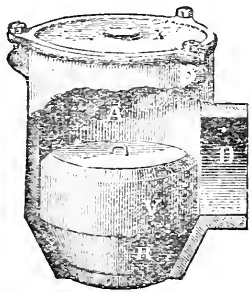


Fig. 38.—Enlarged view of the trap shown in Fig. 37.

C.E., of Ottawa, is one of these. This contrivance *A*, *V*, is attached to the head of the outlet pipe of the street gully or catch basin (Fig. 37), which receives the gutter water at *O*. As the water accumulates in the gully, the plug *V* rises and allows it to flow off through

the outlet pipe *D*: if the water in the gully evaporates or leaks away, then *V* drops into the conical opening and prevents the passage outward of sewer-gas.

257. Where there are traps they are liable to be forced. A trap without a vent is of hardly any practical value. A trap with a protecting depth of water (commonly called the "seal") of three inches, (a three inch seal), only resists a pressure of some two ounces to the square inch. Any person can readily convince himself of the insufficiency of a water-trap without a vent by filling such an one and blowing through it. Without any great exertion he can displace the water and force his breath through the trap. If he now make a vent between his mouth and the water he cannot displace the latter, no matter how hard he blows. The influences, which have been fully considered in Sec. 424, have a powerful action in forcing gas back through traps.

258. Again, traps being emptied by syphoning, sewer-gas may be admitted. If to the end of a trap a tube bent downward be added, it forms the long leg of a syphon, the portion of the trap to which it is added being the short leg; if a full stream be poured through the trap, the water will syphon out of it, leaving the seal broken, as may be proved by experiment. An opening or vent at the arch of the syphon (see *V*, *V*, Fig. 39) will prevent this.

259. The water may be sucked out of a trap by a large body of water rushing down a pipe into which a trapped tube empties. This, again, will be prevented by a vent pipe.

260. Disuse of a trap for a long time will allow evaporation and emptying of the trap and free passage backward of gas. Care must be exercised to see that traps do not leak, and that they are kept well supplied with water. Persons entering a house in which the various services have been long unused should at once turn water into them and open the windows.

261. By absorption through the contents of traps gas is often taken up and given off. Dr. Fergus, of Glasgow, found that ammonia is transmitted through an ordinary trap in about twenty minutes. It is more volatile than other sewer-gases, and fortunately less injurious.

This transmission may be obviated by having, in addition to the extension of the soil pipe through the roof (Fig. 39, *A*), a second main

ventilating tube, *B*, and these two will form a circulation, preventing foul air from accumulating—stagnant—at the traps.

262. In a system of house-drainage, the tube just referred to may be secured by running a 4 inch pipe (*B*) from the sewer, just outside the house wall, up to the roof, clear of cornices, chimneys and windows; whilst the counter opening is obtained by continuing the soil-pipe (*A*) up through the roof. A difference of temperature in the pipes will cause the air to circulate through them. In winter *A* will generally be warmer than *B*, and the current will be down *B* and up *A*. In summer, with the hot sun shining

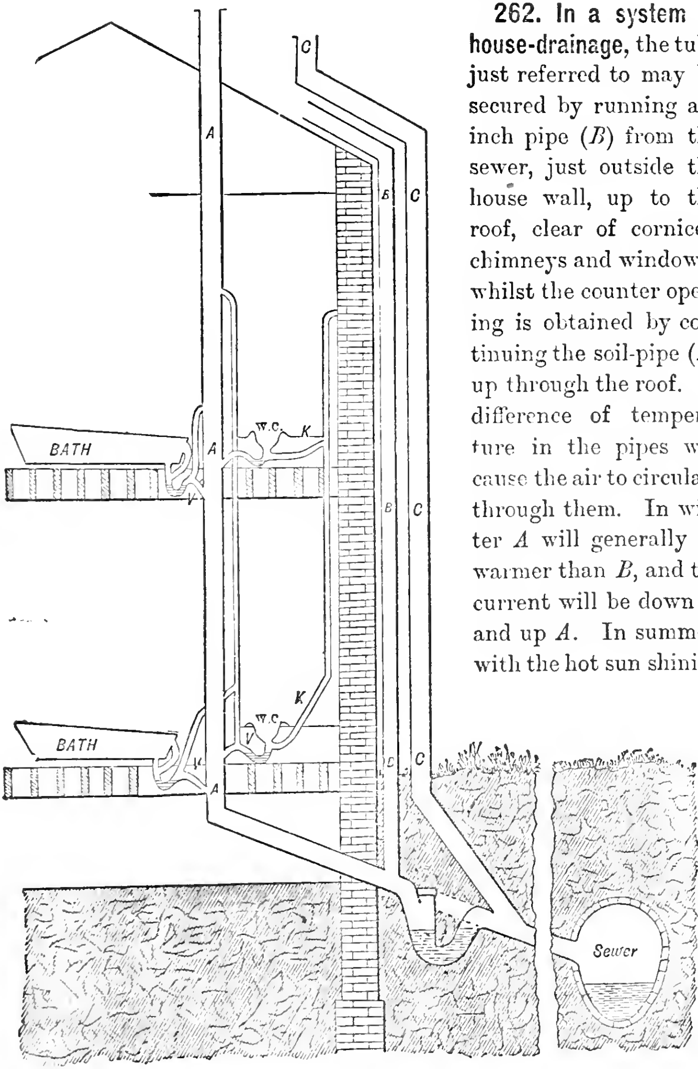


Fig. 39.—Section showing an efficient system of house drainage and drain ventilation.

upon B, the current may be reversed; provided that both pipes run to the roof, this will make no difference; there will in either case be a through circulation of air, and as the two pipes will seldom be of the same temperature, this circulation will nearly always take place.

It will be evident that the practice of some architects in leaving the pipe B cut off short under windows is not in all cases to be recommended. The current will generally be down the short outside pipe, but it may happen to be the other way, as for example, if the short pipe is on the south side of a wall, and the hot summer sun is producing an ascending current up the wall. Again, when a discharge of water or sewage takes place down A, the gas will always be forced up B.

The pipe (A) will save the traps opening into it from being forced by gas from the sewer and drain. The traps of the baths and lower closet —all traps, in fact, below the uppermost one—must be saved by their own vents (V, V, V,) from being syphoned or from having the water sucked out of them by sudden liberations of water above. These vents may open into the extended soil-pipe above the highest trap. In the diagram, pipes (K, K,) will also be seen rising from a point below the hopper of the closet, a little above the water in the trap. These pipes may serve a double purpose. By branches from the water-closet tanks they may act as flushers to the closet traps, and they may also carry off the air from above the closets. They may lead to the outer air or to the chimney-flue of an isolated kitchen in constant use, but never into a bedroom chimney or any other not used *constantly* in the strictest sense of the word. *And never should any tubes which have connection with a drain or soil-pipe open into the chimney of a dwelling-house.*

The trap shown between the house wall and the street sewer might be left out if we had a perfect system of sewerage—one fulfilling all the requisites summed up in Sec. 215; and if the plan we have just indicated were to become generally adopted (as it should be, by by-law, and as it is, theoretically, in every municipality in Ontario, unless where some other by-law has been substituted for that appended to the Act of 1884). The drain would then be carried directly to the sewer, as shown by the dotted lines. But in the present condition of most of our sewer and drainage systems we have to fear that gases of

decomposition and germs of disease exist in many portions of our sewers, and that the inside plumbing may not be perfectly sound and tight. Hence, the best plan is to leave the trap in the position shown, and to have a third ventilating pipe (*C*) running up to the roof from a point just outside of the trap and between it and the sewer. We should thus lessen the possibility of even *diluted* sewer-gas finding its way into apartments through corroded pipes or defective plumbing, whilst at the same time overhead ventilation of sewers would be secured.*

In no case should weeping-drains, wastes from refrigerators or other like appliances have direct connection with the drains or drainage-pipes of the house: their traps are too insecure. (See Secs. 260, etc.)

263. Plans of drainage should be carefully preserved, *e.g.*, by keeping them with the title deeds. Any alterations should be noted on them. Much trouble, uncertainty and expense would thus be saved: mischief is frequently caused by unused and forgotten drains; and material often has to be torn up to search for drains, pipes, traps, etc.

264. It may be well to utter a warning against the pan-closet, a very common form, of which a diagram is here shown. The passage from the bowl into the "receiver" is closed by the pan, holding water and preventing the constant passage backward of gas when the closet is not in use. But when the handle is drawn up the pan is deflected downwards so as to discharge its contents into the receiver, as shown in the diagram; and, as two bodies can not occupy the same space at the same time, there is forced up from the receiver the gas rendered doubly foul by the repeated coatings of fæcal matter adhering to its wall as it is thrown on to it from the pan.

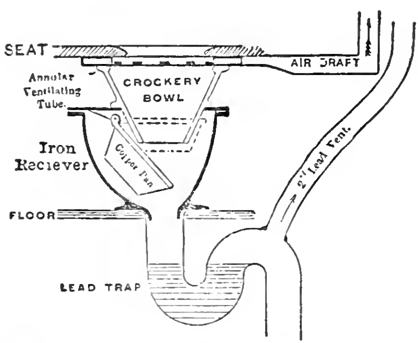


Fig. 40.—A bad form of closet in very common use, the "pan-closet."

* A full discussion on "Overhead Ventilation" may be seen in Vol. IX. of the "Transactions of the American Public Health Association," pp. 233-7 and 396-411, and a synopsis of it in the Second Annual Report of the Provincial Board of Health, pp. 183-192.

265. There are many patent closets whose claims have been vaunted, but none should be used which violates any of the following requisites of a good closet:—

1. That there shall be no opportunity for the lodgment of filth on or in any part of the closet.

2. That there shall be no space between the bowl and trap for the accumulation of filthy slime.

3. No confined space for the accumulation of gases, as in the pan-closet, and others in which there is an air space between the valve or seal of the closet and a trap below.

4. That there should never be, even momentarily, an open communication for the passage into the apartment of gas from the soil-pipe, or from a confined air-space.

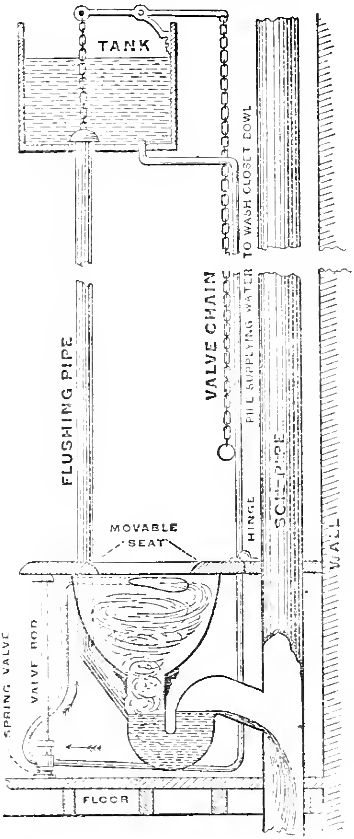


Fig. 41.—A form of closet recommended.

266. The simple hopper with a good swirl of water to keep its walls washed clean whilst in use, and with an occasional flush from a flush-pipe (See Fig. 41), will meet every sanitary requirement and will be free from the objections to which many forms of patent closet are open. In fact it is the best and most simple form of closet.

It has a conical earthenware bowl, the walls of which are completely washed and kept wet when the closet is in use, by a swirl of water from a pipe opening at the upper part of the bowl at an acute angle with its wall; the pressure on the hinged seat is communicated through a rod to a valve in this pipe.

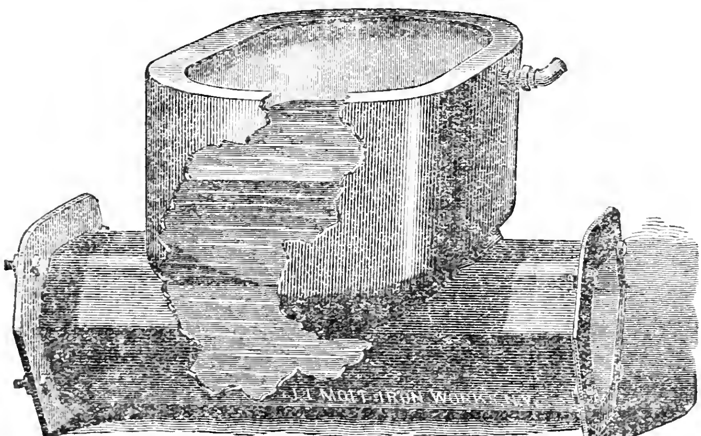
Beneath the closet-bowl is the

trap, the space between the lower end of the bowl and the surface of the water being not more than three inches, leaving the shortest possible space for slime to accumulate, and leaving both this space and the trap readily accessible to the hand, should scrubbing brushes, tumblers, etc., be thrown down. Into this little space a $1\frac{1}{4}$-inch flush-pipe opens, which is an addition for greater sanitary precaution. This flush is worked by a cord communicating with a lever and plug in the tank above. If the tank is not directly overhead a piece of bath chain and pulleys may be employed. No space should be left between the seat and the top of the hopper of water-closets, through which urine or other water may slop over. A foul odor often proceeds from neglect of this precaution.

267. Closet pipes should be supplied from a separate tank, and never from the general system of water-supply. (See Sec. 229.)

Contamination by interchange of contents through leaky pipes carrying respectively water and sewage are on record, and great care should be taken to guard against such an occurrence.

268. That out-door closets in connection with the water-carriage system may be employed in this country is no longer a matter of doubt. In the case of careful individuals a modification of the above closet, with trap deep in the ground, may be so used. But when



(Copyright 1885, by the J. L. Mott Iron Works.)

Fig. 42.—Mott's Latrine.

numbers of persons of various classes have to use closets, they cannot be relied upon for care and cleanliness.

269. Latrines should therefore be used to supersede the privy-pit in the densely populated districts in which the water-carriage system is established, unless it is resolved to use the dry system under corporation management. In many places the change from the old system to the new is being gradually made. No new pits are allowed to be dug; and when any existing one becomes a cause of complaint, it is ordered to be cleaned and disinfected, and filled with fresh earth. These latrines can be controlled by some servant of the corporation, or other person, who shall, from time to time, change their contents, and supply them with water. Of the various forms of latrines, the following may be mentioned :—

270. So-called "iron sinks" are manufactured in various cities on this Continent, and are being largely introduced. One of them is shown in Fig. 42. The hopper or receptacle, and its corresponding section of drain, are made in one piece, and the several portions of drain are then connected. The contents are run off periodically by raising a plug at one end of the drain, and the drain and latrines are refilled. When these are situated outdoors slight artificial heat must be used in winter. These latrines are very moderate in price.

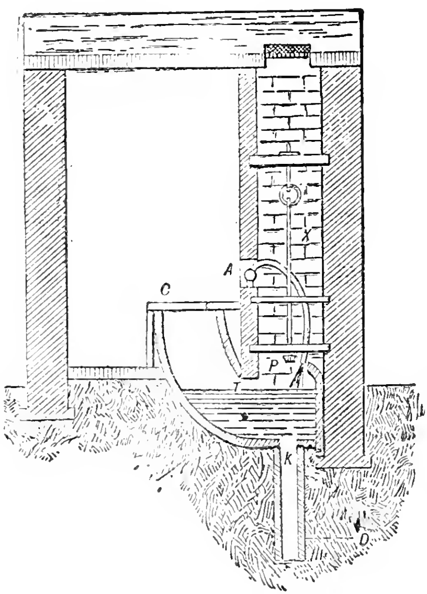


Fig. 43.—Liverpool Trough Closet.

271. The Liverpool trough closet "may be described as consisting of a series of closets communicating with a long trough (T), situated beneath and behind the seat (C), which receives the excreta from each closet in the series. The lower end of the

trough communicates with a drain (*D*), leading to the sewer by an opening (*K*) which is closed by a plug (*P*). Behind the back wall of the closet there is a small space (*X*) to which no one has access but the scavenger," and in which are the plug and a hose connected with a hydrant. They are cleansed and filled as described in the preceding section.

272. The Bristol eject "consists of a strongly constructed dip-trap, interposed between the privy-trunk, as the receptacle is termed, and the drain. It thus admits of the ready extraction of foreign matters which may be thrown in."

273. An advantage of latrines in the event of an epidemic of cholera or enteric fever is pointed out in Wilson's "Hand-book of Hygiene," namely, "it will be an easy matter to throw disinfectants into the troughs, and thus destroy the infectious power of the alvine discharges."

274. If a moderate artificial heat were introduced with the use of such latrines a double gain would have been secured. The exposure to severe cold is sometimes very injurious. Not to enter deeply into the subject, let us take the case of a school-child just recovered from scarlet fever, the peeling of the skin having been accomplished: exposure of the skin to severe cold may produce fatal disease of the kidneys.

275. If, however, these conveniences cannot be heated, we must place the water appliances deeply, as is done now with our water-pipes, hydrant-services and drains, always remembering that the open troughs are more exposed to atmospheric changes of temperature. In this Province out-door latrines and closets without heat have been introduced, and, when carefully constructed, have been found to work satisfactorily in the winter season; but great care needs to be exercised.

Some places, such as factories on the course of our larger rivers, may be so favorably situated as to allow of troughs with a continuous stream; but extreme vigilance, as regards outfall, must be exercised in connection with this practice. Numerous cases of drinking water being polluted by sewage have come under the notice of this and other Boards.

276. Urinals become offensive through want of proper provision for

preventing the incrustation of them with deposits from the urine, and of proper means of frequently cleansing or removing surfaces in their neighborhood. A tray of ashes or sawdust in front of, and beneath, the urinal will meet this latter requirement, the contents of the tray being frequently changed. For the first mentioned cause of offensiveness it seems necessary to have a flow of water washing the urinal whilst in use. Disinfectant contrivances are also used.

277. Intercepting sewers and intercepting tanks are employed in many places where the natural facilities for outfall are not good.

A form of intercepting sewer is shown in Fig. 44. It passes under the sewer (*C*) near the outlet of the latter. When the stream in the latter sewer is small, and the sewage concentrated, it drops through the opening between *B* and *D* into the trough of the intercepting sewer. During a heavy rain, or the operation of flushing, the first and concentrated part falls into the intercepting sewer; but as the volume increases, the velocity also increases, and the stream shoots over the opening, as shown by the stream *A*. The contents of the intercepting sewer are carried off to be disposed of as indicated hereafter.

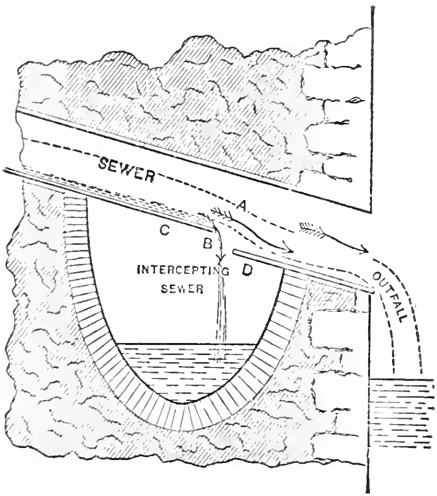


Fig. 44.—An intercepting sewer.

278. Of the pneumatic systems it may be said in brief that they aim at the removal of sewage by drawing it through pipes to central reservoirs or tanks, in which a partial vacuum is created. They are not received with favor by sanitarians in general. The Liernur, Berlier and Shone are the three principal systems.

IV. **279. The ultimate disposal of sewage** when it has reached the outlet of the sewer system presents many difficulties. It may be allowed to flow into large bodies of water, such as our inland lakes, or into

large streams the water of which is not used for drinking purposes, and in which it is so diluted as to be comparatively harmless. There are, however, many objections to the latter method of disposal. If, from situation neither of these methods is practicable, it should be disposed of in some of the following ways :—

280. Precipitation is the term applied to the processes in which the contents of sewers are received into tanks, the solid portions allowed to settle and the liquid to flow off. The settling or "precipitation" is generally aided by the addition of chemicals. The solid settlings are removed and used for manure. They are generally dried, and handled either in the form of powder *(poudrette)* or of "bricks." In these forms it is inoffensive, but as much cannot be said for the various drying processes by which it is manufactured. Lately, however, a method has been invented by which the solid matter is treated by hydraulic pressure, the nuisance arising from the drying process being obviated in this way. The substances which have been used for precipitation of sewage are very numerous; and so, too, are the various combinations of them which have been adopted under various names, such as the A. B. C. process, Lenk's process, Suvern's process, the Lime process, the Superphosphate process, etc. We will merely mention some of the principal substances themselves: lime, alum, iron sulphate, iron chloride, zinc sulphate, sulphuric acid, clay, magnesia, permanganate of potash, ashes, tar, charcoal, etc. With the use of some of these chemicals the liquid is so purified as to need no further treatment.

281. Intermittent downward filtration is the term applied to the method which has been adopted in some places where it has been found impracticable to use the liquid as manure, and where it has not been rendered pure by chemical precipitation. A small quantity of waste land is under-drained at a depth of from four to six feet, and the sewage flows over it. By the action of the air contained in the soil, and of the roots of vegetation, it is purified, and then flows through the sub-soil drains into the nearest water-course. The same process is repeated on another portion of the land, and then on another; and by the time the whole surface has been treated in this manner the first portion is ready again to receive the sewage, the soil having had time to dry and re-absorb air.

282. **Irrigation** is a method by which liquid sewage is applied directly as manure, the fields being irrigated with it, either by means of surface trenches or open-jointed drain-tile pipes, laid about a foot below the surface. The soil should be under-drained, and the sewage should be applied on the intermittent principle explained above.

Sewage farms have been worked for a good many years in England and on the Continent of Europe; and although at first they were looked upon in many instances as public nuisances, yet of late years, with increasing experience and resulting improved methods, they have been gradually growing in public favor. It seems to be the general testimony of medical men, chemists and others, that, when properly managed, they are in no wise injurious to the health of the people in the neighborhood, and that the produce of such farms, both animal and vegetable, is as wholesome as that of any other.

On a sewage farm there should be at least three sets of fields, viz.: one for summer irrigation, a second for winter irrigation, and a third for what may be called storm-water and residual irrigation. The fields for summer irrigation are treated regularly with the sewage during the growing period of the crop. When the harvesting of the crop or other circumstances render it necessary to stop the irrigation on the fields, it is directed onto the residual irrigation fields. This is also done during storms or floods, in cases where the storm-water passes through the sewers. The fields for residual irrigation are best kept in grass, and may be used for pasture.

283. **During the winter** the sewage is directed on to another set of fields. These are ploughed in the spring and cultivated during the ensuing season without any further addition of sewage, that received during the winter generally proving sufficient.

284. **The experience of Dantzic, and of the State Insane Asylum, Augusta, Maine**, have tested the practicability of this method of sewage disposal in winter. "The sewage flows out under the snow through the many furrows prepared for it, leaving a thick crust to be ploughed into the land in the spring. . . . When the mercury stood at nearly 0° Fahr., and the ground was frozen hard, the sewage was found to disappear very soon after it was put on the land. In the spring the early rains wash any refuse that there may happen to be

deep into the soil, and no offensive odors are noticed. The surface of the ground is then sometimes found covered with a brownish scum."

These experiments are of great value as solving a question which naturally arises in connection with the climate of this country.

As a general rule systems of sewage disposal are not made to pay their own expenses by direct money returns. The aim is rather to minimize the expenses entailed by such disposal as shall lessen the amount of death and disease occurring amongst us. In connection with Pulman, Ill., however, there is a sewage farm,. the crops from which are said to yield a good rate of interest on the money invested.

285. Over and over again the death rate has been materially reduced by the introduction of improved methods of disposal of excremental products, showing that many deaths are annually caused by the filthy methods at present in existence. The young are most susceptible to the baneful influences of these methods; and as this work is especially designed for the use of teachers in our schools, we would in this matter, as well as in the ventilation of schools, ask them to use their influence to bring about better conditions; to use whatever discretionary power is left to them, and also to agitate, not only with school trustees, but with citizens at large, the adoption of hygienic methods.

286. Especially let our men remember that there are in attendance at schools, both as teachers and scholars, those who, from motives of delicacy, will not refer to this subject themselves, and whose delicate organization leaves them the more susceptible to the evil influences of the unsheltered and filthy places to which they must sometimes resort. This remark will apply also to those of the other sex who are engaged in business houses and other public places. Shall it be said that men who strive to show their thoughtful politeness in other matters, sometimes in mere formalities of etiquette, shall, in connection with this matter, allow those who cannot speak for themselves to be subjected to such injurious and disgusting treatment?

CHAPTER X.

INFECTION AND CONTAGION—NATURE OF INFECTIOUS DISEASES—MODES OF PROPAGATION—MEASURES OF PREVENTION.

287. The terms contagion and infection are used to denote the propagation of disease from one individual to another; and also the matter by which the propagation is effected. We have perfect knowledge that this propagation is sometimes effected by inoculation; and from analogy and from our inability otherwise to explain the phenomenon, we infer that in all cases of contagion there is a communication of such matter.

288. Contagious diseases may be divided into those whereof the contagious matter acts only by positive contact between the individuals communicating and receiving the disease, or by its transference in a visible form from one person to another by inoculation, and those which, are also capable of transmission from individual to individual through the medium of the atmosphere. Contagion is, therefore, immediate or mediate, contactual or remote. To the former division are to be referred itch, ring-worm, Egyptian ophthalmia, some varieties of skin and other diseases; to the latter, small-pox, chicken-pox, measles, scarlet fever, diphtheria, whooping cough, typhus fever, typhoid fever, hospital gangrene, puerperal fever, etc By some the term contagious is limited to the first class mentioned, but the distinction is not general amongst writers on the subject.

289. Diseases are said to be epidemic when they attack a large number of individuals simultaneously. They are said to be endemic when, as is the case with malarial diseases, they are limited to a certain territorial district, and exist there either continuously or for an indefinitely long time.

290. As far back as history goes we find records of devastating scourges. They have destroyed, remarks Liebermeister, the armies of conquerors, have been the means of removing whole races of man-

kind from the earth, and have given death-blows to advanced civilization. In the fourteenth century the most deadly of all the pestilences recorded in history, the Black Death, changed the direction of intellectual and social activity throughout the chief part of the civilized world. Throughout Europe more than a million of lives fell a prey to this scourge. Italy lost one-half of her inhabitants; and in England, if cotemporary statements were not overdrawn, scarcely one-tenth of the inhabitants were left.

291. Among the causes that have lessened epidemics are advance of civilization, the improved sanitary conditions under which we live, and our increasing knowledge of the nature of epidemic diseases and the way in which they are propagated.

292. The modern hypothesis of infectious diseases is that of a *contagium vivum*, viz., that the poison of infectious diseases consists of living organisms. This idea, however, has not the merit of absolute novelty claimed for it. The Roman authors of *De Re Rusticâ*, Varro and Columella, refer the origin of many malarial fevers to the entrance of a low order of organisms into the body. Within the last few years investigations of the appearance, mode of propagation, and nature of these organisms, new facts in regard to the extension of infectious diseases, and a number of positive discoveries have furnished definite proof of the correctness of the "germ theory" of these diseases. To discover the contagium of the vaccine disease the microscope was used, and Dr. Lionel Beale, in December, 1863, announced the discovery of transparent vesicles of extreme minuteness in vaccine lymph, and expressed his conviction that the contagious or active properties of the lymph lay in these particles. The correctness of these observations, now admitted as being without doubt, was subsequently verified by other scientific men. The germs of various contagious diseases have been isolated and cultivated in broths and other "culture fluids," in which they have multiplied rapidly; the germs resulting from these cultivations have been found to produce in animals results similar to those observed in the animals from which the parent germs were taken. In some instances, the diseases so produced have been less severe, and have been found to act as protectives against the more severe forms. The labors of Pasteur in this direction bid fair to prove a boon to mankind in the mitigation of hydrophobia; they

have already lessened the mortality from charbon and chicken cholera among the lower animals. Quite recently, Dr. Ferran has been endeavoring to obtain similar results with the germs of Asiatic cholera, with what success we have not yet sufficient evidence to enable us to determine.

293. **The characteristic quality of a contagium vivum,** or virus of a communicable disease, is its capability of undergoing almost unlimited multiplication when introduced into an appropriate medium. This power of development and this faculty of breeding true, were the first, and have ever been regarded as the chief, arguments in favor of the germ theory of disease; and it is difficult, remarks Dr. Maclagan, to see how these properties of contagion can be accounted for on any other view of its nature.

294. **Each virus has a definite and specific action,** although the symptoms may vary with the dose of the substance introduced. The effects may be modified by temperament or constitutional peculiarity on the part of the recipient, and after a time the substance may be eliminated from the system.

It may now be concluded beyond dispute that infectious diseases are induced in the system by a morbific agent which is propagated in, and given off by, the bodies of the sick, and is capable, when received into a susceptible, healthy body, of producing in that body a disease similar to the one during whose course it was formed.

295. **Therefore every infected person becomes a breeding place of disease.** An examination into the natural history of these infecting particles, or contagia, demonstrates them to be organized structures—living entities—called *germs*, *micro-organisms*, *microbes*, *micro-zymes*, etc., and divided up into *bacilli*, *bacteria*, *vibrios*, etc., according to differences in their forms and other peculiarities. Like all living things, they are endowed with properties designed for their propagation and continuance. Each disease has one or more channels by which its special contagion is eliminated.

296. **In giving a brief description of infectious diseases** we will only refer to those diseases, and those features of them, which may be of general interest or use. The disturbance of the system occasioned by them is sometimes so slight that they are overlooked. It is therefore desirable that teachers, railway officials and others should have such

knowledge as may draw their attention to cases of this kind, in order that proper steps may be taken, the advice of a physician being obtained when necessary.

297. There are certain premonitory symptoms in most of these diseases, such as lassitude, headache, heaviness, diminution of appetite, thirst and slight heat of skin alternated with chilliness. Of course, an attack may occur without all of these symptoms being present. There are also differences as to their prominence in the different affections, and even in the same affection in different individuals; still more marked are the differences in their duration.

298. In measles they are generally present for some days. They are followed by a watery condition of the eyes and nose, sneezing, sometimes cough and hoarseness. About the fourth or fifth day small, circular red spots, slightly raised, appear on the face, and spread to the body. These gradually run into half-moon shaped patches, with skin of the natural color between them. About the seventh day the rash begins to fade from the entire body, and lessens in brightness during the succeeding days, or gradually disappears by desquamation, accompanied by much itching. Occasionally a malignant form, with very dark-colored spots, is seen, to which the name of "black measles" is popularly given.

299. In scarlet fever the premonitory symptoms are often of much shorter duration, the rash appearing suddenly. It consists of red spots, brighter, more minute and more thickly sprinkled over the skin than in measles, which soon unite into a continuous scarlet rash, with no intervening skin of natural color. It is usually accompanied by sore throat, swelling and tenderness of the neck and enlargement of its glands. The disease varies very much in severity; sometimes it is so malignant that the eruption is mattery, and the throat is very badly ulcerated. Other cases are so mild as to be overlooked altogether, or till some of the after-effects (or sequelæ) cause enquiry to be made and the previous existence of a slight rash or redness to be remembered. These are the cases which are most likely to call for the watchful scrutiny of the teacher. It is worthy of remark that the after-effects are not by any means to be measured by the mildness of the attack. The rash subsides usually between the fifth and seventh day, and is followed by the desquamation or peeling of the skin, which comes off

in flakes more perceptible to the eye than those of measles. This lasts several weeks.

300. Rötheln, or "German measles," partakes of some of the characteristics both of measles and scarlet fever. It is more apt to recur than either of these diseases.

301. In diphtheria, too, the onset is generally more sudden. The characteristic sign is the deposit of yellowish patches on the tonsils, palate, back of the throat or nasal passages, or, in the more severe cases, in the windpipe and bronchial tubes. There is frequently swelling of the face and of the glands and other tissues of the neck; also a discharge from the nose and eyes, often of a more yellowish color than in measles. Sometimes these latter discharges are present before true diphtheritic patches have appeared in the throat.

In mumps (inflammation of the parotid gland) there is stiffness and painful swelling about the articulations of the jaws, without sores in, or discharge from, the throat or nose.

302. Whooping cough generally commences like a common cold, with watery eyes, sneezing and a dry cough. After a time the cough becomes spasmodic, consisting of a long expiration, broken by a number of short, jerky coughs, the walls of the chest and the diaphragm being spasmodically compressed to the utmost degree, expelling the air, then by a quick movement a long breath is drawn in, sometimes causing a "whoop," and the process is repeated. The disease is supposed to be most infectious during the early or catarrhal stage.

303. In chicken-pox (varicella) the premonitory symptoms generally last a day or two before and after the first appearance of the rash. This usually breaks out first on the trunk, and afterwards slightly on the face. At first there are small red elevations, irregularly round in shape. Small pearly vesicles soon form in the centres of these, become milky, shrivel up about the fifth day, forms scabs and crumble away. Successive crops appear on the same parts.

304. In small-pox (variola) the premonitory symptoms are more severe—there is much aching of the back and loins—the rash comes first on the face, at the roots of the hair, occasionally on the hands. It then spreads to the neck and trunk. Red spots first appear, increase in size, and are depressed in the centre. About the second day of the eruption these become vesicular, and between the fifth and

seventh days pustular. If these pustules are unbroken they become thick brown crusts, and drop off in this form.

305. In varioloid, a mild form of small-pox, these symptoms and appearances are less marked, and run their course more quickly.

On comparing small-pox and chicken-pox, it will be seen that the differences in the time and place of the first appearance of the rash, and its mode of disappearing, will aid us in distinguishing between them; also the facts that, though some of the vesicles in small-pox may be slower than others, they do not replace each other by successive crops, and that the symptoms are not so severe. Some of these differences will also help us to distinguish between varioloid and chicken-pox, though the differentiation is more difficult. In all suspicious cases a physician should be called upon. What is here considered of importance is to point out to the teacher, or other person interested, the symptoms and appearances which should draw his attention to them.

306. In typhoid fever the premonitory symptoms are of long duration. The continuous fever and persistent headache are very characteristic. We may employ even less detail in describing this disease: it is only the discharges from the alimentary canal that convey infective germs (and the physician will order the disinfection and disposal of these), so that we need not be on the watch against infection from the persons of those suffering from typhoid fever.

307. Cases of Asiatic cholera will naturally be brought at once under medical care. The severe purging, vomiting, cramps and prostration will be sufficient indications to those who wish to give to the sufferer prompt assistance in the meantime. This will consist of hot applications to the surface and extremities of the body, mustard or turpentine to the abdomen, and stimulating and nourishing drinks. The alvine discharges are the vehicles of infection in this disease also.

308. Itch (scabies) is spread by contact only. It consists of small watery vesicles, something like the commencing vesicles of "cold sores" on the lips, but they are always small and semi-globular. They result from the burrowings of a small insect (*acarus scabiei*). They usually occur first in the thin skin of the interspaces between the fingers and of the bends of the elbows and knees; they then spread to other parts of the body. Sometimes, however, especially in cold weather, they are to be found about the body, and more particularly

about the waist where the clothes fit closely, and not on the hands. The rash sometimes loses its characteristic appearance in consequence of the violent scratching which takes place.

309. To the various forms of "ring-worm" we would also draw attention. The form commonly seen on the body consists of a furfuraceous or scaly spot, gradually extending its circumference, and leaving a healthy portion in the centre. On the head it is sometimes of the pustular variety.

310. There are forms of contagious and other diseases which, unfortunately, at times affect both the innocent and the guilty, of which we cannot treat in a work for general use. We would merely say that it would be well for those who have any controlling or directing influence, and desire to use it in a proper direction, not to shrink from seeking information from some medical friend or adviser, when they see that such information may be of service to themselves or others.

311. In different diseases different parts of the body supply the contagion. Those parts which are most implicated are the breeding places of the contagious particles and give off the poison in the greatest amount; for example:—In scarlet fever, the throat, mouth and nasal passages, the skin and other excreting organs; in diphtheria, the mouth, throat and nasal passages; in measles, the skin and air passages; in whooping cough, the air passages; in typhoid fever and cholera, the discharges from the bowels convey the germs of disease; in small-pox the pustules of the skin and throat, more especially of the skin; the discharges and eruptions in syphilis, glanders and malignant pustule; in typhus fever the skin and air passages are greatly affected, and it is generally supposed that it is from them that the virus spreads.

312. The modes of conveyance of contagious particles may be best understood and appreciated by taking up the consideration of the methods in which we know some of these diseases are spread; and first of all we will take up that disease which has the greatest number of channels of propagation, viz.:—

313. Scarlet fever, which may fairly be considered as the most infectious and intensely fatal of the more common infectious diseases: according to the statistics of Dr. Farr, the annual mortality from scarlatina in England and Wales, from 1848 to 1855, comprised one-

twenty-fifth of the entire death-rate. The following are some of the modes in which scarlatina poison is transmitted:—1st. Association with a person sick from the disease. 2nd. Exposure, even though brief, to the same atmosphere whether in a room or conveyance, either during the time the sick person is in it, or before it has been made free from infection. 3rd. Occupation, even after a lapse of time, of a room that has been used by one sick with scarlet fever, and which had not subsequently been thoroughly disinfected. Dr. Benedict, in *The Lancet*, cites a case where several children were seized with the disease immediately after their return to a room in which the decease of a scarlet fever patient had occurred two months before, and which in the interval had been cleansed with much care. The germs were probably retained in the wall-paper. 4th. Exposure to evaporating secretions of scarlet fever patients, not only as they arise from the body, but as they remain upon clothes or in vessels in any occupied apartments. It is highly probable that all the secretions and excretions are impregnated with the contagion. 5th. The use of clothing which has been worn by one sick from scarlet fever. Many cases are on record where the disease was caused by garments a very long time after the death of the patient who had worn them. 6th. Occupation of a bed, or the use of lounges or carpets or upholstered furniture not thoroughly disinfected after use by a scarlet fever patient. A medical man relates a case where a carpet, removed from a house in which a family had had scarlet fever, to another part of the town, communicated the disease to other children. 7th. There is an overwhelming amount of evidence to show that persons, themselves unaffected by the disease, may, either upon their persons or their dress, bear the poison of scarlet fever long distances to others. Articles of almost every description which have been used by, or exposed in the room with, a scarlet fever patient have been known to do the same. Dresses made in a milliner's house where there was scarlatina, and sent to a family living in a secluded country district, as also children's toys used in convalescence, and sent afterwards to other children a long distance off, have proved vehicles of infection. Dr. Richardson relates cases where the poison has been transmitted a long distance by letters and books. This is a matter of great importance in connection with circulating libraries. 8th. Domestic animals from the houses

of persons ill with scarlet fever spread the disease. 9th. Going near the body of one dead from scarlet fever. A medical man from Winchendon relates a case where forty persons attended the funeral of a child that had died from scarlet fever: thirty-seven took the disease. Many other equally striking cases are on record. The evidence is such as to leave no doubt that the duration of the virulence of scarlet fever germs, if not destroyed, is to be measured by very many months, or even by years.

314. Diphtheria is intensely contagious. The nature of the particular parasite is still an object of dispute. The contagion may be carried through the air, or by solid matters to which it has attached itself. It is, therefore, diffused by the exhalations of the patients and by the air surrounding them, as well as by contact of various objects with the products of the disease.

315. Measles.—Every object which has in any way come in contact with infected persons, or has been in their atmosphere, may serve as a vehicle of contagion.

316. Whooping cough would seem to be due to the action of a germ on the respiratory nerves and membrane lining the lungs, the secretion from which contains the infectious matter. From it may be exhaled in a gaseous form the specific virus, and thus the reception of the contagion by other individuals is effected by the impregnated atmosphere of the room. The contagion may not only be exhaled, but the sputa may prove infectious from the development of gases. By some authors this quality is even ascribed to the dried expectoration. Healthy persons should therefore avoid handkerchiefs, towels, etc., which have been used about children suffering from this disease. It is of the first importance to prevent persons suffering from it from meeting those who are well. Delicate, feeble children, and even adults, should be especially guarded against the contagion, and no catarrh of the respiratory organs should be regarded as trivial during the prevalence of whooping cough. This disease is so frequently fatal to infants, that no reasonable effort should be spared to keep them out of the range of its infection. It may even affect persons in middle life, or of the most advanced age, if not protected by a previous attack.

317. That consumption is communicable by germs expectorated or

exhaled from the lungs is an opinion long entertained by many physicians. Professor Koch and other microscopists claim to have discovered the special microbe of this disease, and their observations have been verified by many other observers. Besides, reports have recently been presented by physicians, of cases in which they believe that consumption was caused in persons of good constitution by their inhaling the breath of those suffering from the disease. Of course, it is well known that in very many persons it is the result of hereditary weakness; and that in many others it is caused by foul air, and other insanitary conditions; but the statements above referred to seem to indicate that it may be ranked as an infectious disease. Hence an additional reason is presented for free ventilation of the rooms inhabited by consumptives. Care should also be exercised by persons associating with those affected with this disease, and the expectorations should be disinfected and destroyed.

318. Typhoid, or enteric, fever is spread by the excreta of patients. Petenkoffer regards the ground air (see Sec. 188) as a very frequent, if not in some localities the chief, mode of conveyance of the contagia of enteric fever and cholera. The next universal medium is water, which is undoubtedly the means of carrying rapidly the infectious particles. Articles of food are also vehicles of infection, and amongst these milk is one of the most ready absorbents. Dr. J. B. Russell, medical officer of Glasgow, considers that the enteric or typhoid contagion multiplies in milk—a vital fluid almost as appropriate for its nutrition as the blood itself: he argues that it is scarcely possible in any other way to account for the virulent infecting power of contaminated milk with what in many cases must be an infinitesimal quantity of the original virus.

319. Asiatic cholera.—Quite recently notices have appeared of discussions by Professor Koch and others, regarding his alleged discovery of specific germs in the dejecta of persons who had died from this disease, which have, when injected into animals, occasioned rapidly a similar train of symptoms, ending in death.

320. The period of incubation is the term applied to the time which elapses between the reception of infection into the system and the development of morbid symptoms. To correctly determine the duration of this period in the various diseases is a matter of great import

ance. In some it cannot be stated very definitely, but it has by repeated observations been established within certain limits as follows: in small-pox, from seven to twenty days, twelve being the most common period; in scarlet fever, from one to ten, seven being the most common; in measles, ten to fifteen days (Murchison). The exudation of diphtheria, if transplanted, may begin to grow at once; how long after exposure it may be dormant has not been determined. Many authorities believe it may arise spontaneously; but all are agreed that, when it does exist, it is extremely contagious. In mumps the incubative period ranges from eight to twenty-five days. In whooping cough and typhoid fever it has been found hard to determine, but it is believed to be about two weeks in the former and from two to three weeks in the latter. In chicken-pox it is from ten to twelve days, although some make it much longer. In all the above the period is reckoned to the commencement of the premonitory symptoms and not till the appearance of the rash, or other distinctive features.

321. The duration of contagiousness is a question of even greater importance, since upon it depends the time during which those affected must be kept apart from those who have not been. In the eruptive fevers it is a good rule to continue isolation of the patient till some days have elapsed since the cessation of desquamation or throwing off of shreds of skin and infective particles. In scarlet fever and small-pox this may vary from four to eight weeks after the commencement of the disease, longer in small-pox if the hair is not carefully freed from scabs; in measles, mumps and diphtheria it is much less.

322. It is a fact too commonly overlooked that in scarlet fever it is during the period of convalescence and peeling of the skin that the contagion is most apt to be carried and propagated; also, that this peeling may not begin for some days after the patient is apparently well. In this disease it is most necessary to keep from school not only the patient, but all who come in contact with him, or whose clothing may become infected. There is possibly no contagion so lasting as that of scarlatina: hot weather does not seem to render it inert to the same degree as it does that of small-pox. Nor have we as yet any protection against it such as that afforded by vaccination in the case of this last named disease.

323. A mild case may prove as infectious as a severe one, nor can we be sure that resulting cases will also be mild. It may be well to correct another popular error, namely, that scarlatina is a mild form of scarlet fever: they are identical, the former being the medical synonym of the latter term. Varioloid, on the other hand, is a mild form of variola (or small-pox), often occurring in persons who have at some time been vaccinated.

324. A person should be kept separated from all other persons except necessary attendants, when there is reason to suppose that he has one of the above mentioned diseases, and until it be ascertained definitely whether he has such disease.

325. Every case of diphtheria, scarlet fever, small-pox or typhoid fever should be at once reported to the Health Officer appointed by the Local Board of Health, as required by the Public Health Act.

Every person known to be sick with scarlet fever, diphtheria or small-pox should be promptly and effectually isolated from the public; no more persons than are necessary should have charge of the patient, and these should be restricted in their intercourse with other persons.

326. Persons should be isolated in their own homes whenever it is possible without danger to others. Humanity, prudence, and economy dictate this. In some cases it cannot be, hence hospitals for infectious diseases must be established. These should be made as cheerful as possible, and in the case of a young child provision should be made that some member of its family may accompany it, if desirous of so doing. Tents may be made cheery and comfortable; they can be made warm by having a double wall with intervening air space, and a stove. They have the great advantage of being easily subjected to disinfecting solutions, and they are cheap, portable, and capable of speedy erection. They should be provided with hardwood floors. An illustrated description of such an one may be found in the Second Annual Report of the Provincial Board of Health.

A sheet wet with a powerful disinfectant (Sec. 330) should be hung across the door-way of the room in which there is a person ill with scarlet fever or other severe infectious disease.

327. Notice should be placed on every house in which a case of scarlet fever, diphtheria or small-pox exists, and no person should be allowed to enter unnecessarily. The system has been carried into effect

with the object of warning persons not to go in and out of such houses without proper precautions. This is required by the Health By-law in force in most of the municipalities of Ontario; but in very many it has not been put in operation, owing partly to the fact that health organizations generally grow slowly, and partly to the selfish objections of some persons and the sentimental objections of others. Humane and conscientious people, when they have infectious diseases in their house, take a great deal of trouble to warn people away from the door by word of mouth, and many of them have the good sense to see that the placing of a placard on the door will save them much trouble, and they ask that such placards may be supplied them. Selfish persons object, lest it may injure the pecuniary receipts from their business; and some foolish people resent the system as an infringement of personal liberty. But our Health By-laws suppose the householder will be so humane as to be willing to affix the placard himself, so that the system may become general. In some places, where objections were at first raised, they gave way to a little common sense. For example, Dr. Wight, Medical Health Officer of Detroit, one of the first cities on this continent to establish the system, thus writes:—

"At first the people objected to having their houses placarded, as a violation of personal liberty. A little argument convinced reasonable citizens that no man has the natural or acquired right to expose his neighbors to deadly contagious disease by concealing it in his own house. Personal liberty to give small-pox to somebody else had better be abridged as soon as possible. Personal liberty to send scarlet fever into a school with your child is rather diabolical than beneficent. A law-abiding community submitted, and to-day the system of placarding, if it were left to an election, would receive a majority of votes in its favor. Experience proves its value in many ways to the citizen. He knows and feels that, by reason of it, his family is more secure against diseases that cost money, anxiety and sorrow."

328. The bed-room of a person sick with any infectious disease should be cleared of all needless clothing, carpets, drapery, or any material liable to harbor the poison of the disease. The room should be large, having an air-space of at least 1,000 cubic feet for each one of the number of individuals likely to be in the room at the same time; it should have a liberal supply of fresh air—at least 3,000 cubic

feet per head per hour. In summer the supply should be unlimited; windows should be thrown open, and draughts on the patient prevented by a fine gauze or wire netting, slanting from the top of the sash to within two inches of the ceiling.

329. Discharges from the throat, nose and mouth should be received, or immediately placed, in vessels containing some suitable disinfectant; if on rags or handkerchiefs, these should be immediately burned. Likewise, the discharges from the kidneys and bowels should be passed into vessels containing a pint of disinfectant, and immediately buried at least a hundred feet from any well or other drinking-water supply. If the soil is sandy or porous, or if the above precautions are impracticable, the discharges should be placed on old cloths, which should immediately be burned.

330. The following is a list of disinfectants, based upon the experiments of Miquel, Sternberg, and others.

1. Solution of corrosive sublimate: 1 oz. to 4 galls. To this may be added potassium permanganate, 1 oz., which gives it a color lessening the danger of its being mistaken for water, whilst it is a useful disinfectant.
2. " sulphate of copper: 1 lb. to 5 galls.
3. " chloride of zinc: water, 1 gall.; sulphate of zinc, 4 oz.; common salt, 2 oz.
4. " chloride of lead: dissolve 2 drachms of nitrate of lead in a quart of water—then, in a larger vessel containing a gallon of water, dissolve 2 tablespoonfuls of common salt (sodium chloride); mix the two solutions together, and store for daily use.
5. " carbolic acid: say 1 part in 20 to 40 of water.
6. " copperas: 1½ lbs. commercial sulphate of iron to 1 gall. water.
7. " chlorinated soda (or lime).
8. Carbolate of lime.
9. Chlorine fumes: peroxide of manganese, 1 part; sulphuric acid, 2; sodium chloride, 3; water, 2. To be mixed in a glazed dish, and placed on a warm stove or other heating surface.
10. Fumes of burning sulphur (sulphurous acid).
11. Heat: 212° to 250° Fahr.

331. The purposes for which these disinfectants are severally most suitable may be thus indicated :—

5 and 7, diluted with equal parts of water, may be used for washing the hands and other parts of the body. 3 and 4 may be used for cups and other utensils; these, if employed for drinking purposes, should be rinsed in clear water after using the disinfectant.

A 1, 3, 4, 9, 10 and 11 may be used for bedding, clothing and other textile fabrics. Carpets, curtains and other colored articles, besides being cleaned by ordinary processes, should be exposed to the action of heat (11) for several hours. It must be remembered 9 and 10 have bleaching properties, especially the former. 1, 5, 9 and 10 may be used for the wood-work of furniture without fear of injury in the highest strength mentioned. 5 should be employed for scrubbing floors. 2 and 6, especially the former, may be used for disinfecting privies, excreta, etc.

332. Extreme caution should be used in the storing of these disinfectants, especially those which are colorless and odorless, as most of them are strong poisons.

333. For the purification of clothes and bedding, the best plan, where practicable, is by the agency of heat. Dr. Henry, of Manchester, disinfected scarlet fever clothing by exposure to 212° Fahr. for one hour. A brick oven or portable furnace will answer the purpose, the clothes to be disinfected being hung on wires. Boiling clothes is not so good as baking, but still is useful. Clothes may be laid for twenty-four hours in a solution of chloride of zinc in the proportion of 1 to 240, or in the chloride of lead solution described above, and then they should be washed with soap and water if they cannot be baked.

334. Nurses and attendants should keep themselves and their patients as clean as possible; they should disinfect their hands frequently by chlorinated soda or other disinfectant. They should also wear cotton or linen (not woollen) clothes or overalls, to which particles will not so readily adhere, and which may be more easily disinfected.

335. No person recovering from diphtheria should associate with others, or attend any public assembly, until the throat and sores on the lips and nose are healed for some days; nor before he can, in the judgment of his physician do so without endangering others; nor until all his clothing has been thoroughly disinfected.

336. The disinfection of dwellings and premises after recovery or death should be carefully attended to. In addition to thorough cleansing of all wood-work with soft-soap, and with water to which carbolic acid has been added (one pint of the common liquid to four gallons of water), and in addition to removing and washing all fabrics which can be removed, as indicated in Sec. 333, and brushing the walls, the rooms should be fumigated for a period varying from three to twenty-four hours with sulphurous acid. A metallic dish should be suspended over a tub of water, or should have ashes placed in it. All doors, windows, and other apertures being tightly closed, sulphur, mixed with saltpetre, is to be placed in the dish and lighted. The proportions should be 2 lbs. of sulphur and 3 or 4 ozs. of saltpetre for every 1,000 cubic feet of air space. In a very long room it is best to have the sulphur in two or more places. After the lapse of a period varying from six to twenty-four hours the doors and windows should be opened, and kept open for several hours. In disinfecting in this manner the person setting fire to the saltpetre and sulphur must make a precipitate escape from the room the instant the sulphur is burning. Dr. Russell recommends that previous to the use of the sulphur fumes every part of the room—ceiling, walls, floor—should be carefully dusted down and the dust collected and burned. Then, that every part should be washed down with the carbolic soap and hot water, and that while all the surfaces are wet the sulphur should be burned. The object of fumigating while the surfaces are wet, is to insure absorption of the sulphurous acid fumes by the water, thus destroying any germs lying in the cracks. If these infectious particles are dry the gas will not penetrate into their substance. Carpets fumigated on the floor should afterwards be removed to the open air and thoroughly beaten.

337. Pillows and feather beds, mattresses and upholstered furniture, after being disinfected on the outside, should be cut open and their contents exposed to the fumes of burning sulphur. In no case should the disinfection of clothing and bedding be omitted. When any infected articles are to be burned, they should be placed in a close stove, unless they have been previously disinfected.

338. People should avoid unnecessary exposure to special contagion. There is more danger for children than for adults. It is bad reason-

ing to say that children must have these diseases, and to be therefore careless about infection. If the same earnestness were shown to avoid scarlet fever and whooping cough that is shown in reference to small-pox, we would be equally free from these diseases. A perusal of Secs. 311–319 will show the sources of danger to be avoided, and Secs. 324–337 will show how we are to combat infection.

339. In the event of small-pox appearing in a neighborhood, care should be taken to cause every person who has not been vaccinated within seven years to be vaccinated or re-vaccinated, as the case may be.

The statistics of epidemics of small-pox show that the great majority of those attacked have never been vaccinated, and that the numbers decrease in inverse proportion to the number of good vaccine marks to be seen. Moreover, vaccination modifies the severity of small-pox, even when it has so far failed of its effect as not absolutely to prevent the infection. Observations show that the well vaccinated as they become older take the disease in a slight form, the badly vaccinated in a very much worse form, and those who have not been vaccinated at all are subjected to the worst and most fatal forms of the disease. The badly vaccinated individual is only a little less susceptible than the individual who has never been vaccinated at all. Every person who has been vaccinated should report himself to the practitioner who vaccinated him, so that the latter may judge of the character of the vaccination. If re-vaccination has "taken" well a few years before, this is, if anything, an extra reason for further re-vaccination, for it shows that the person is naturally susceptible. Even persons who have had small-pox may take it again, and should therefore be vaccinated.

340. Special attention should be paid during the prevalence of any epidemic to sanitary requirements in general, such as are indicated throughout this work. We must ever bear in mind the necessity for absolute cleanliness in our midst, so that epidemics may find no filth upon which to feed and grow.

341. Methods of quarantine and sanitary cordons have of late been subjects of much practical discussion. Instead of the time of quarantine being spent in tedious waiting, as was formerly too much the case, vigorous measures of combating the germs of disease are now taken. The means to be adopted for preventing the importation of disease and

limiting its spread were well set forth at a conference of representatives of Boards of Health of the United States and Canada, held in 1884. The following are the chief features of the scheme :—

Consular or other officers at foreign ports of embarkation should, during times of serious epidemics, acquaint themselves with the sanitary condition of vessels and passengers bound for the United States or Canada, and whether the latter have come from infected districts. They should, if requested by the owner of any such vessel, inspect it, prescribe such sanitary measures as may be necessary, and give a bill of health. They should telegraph to the Central Board, on the departure of any vessel leaving an infected port, or suspected of bearing infection. Steamship owners should be induced to have sanitary measures strictly enforced during the voyage. On arrival at the port of debarkation (on this side) the quarantine officers should follow up, as occasion may require, the measures inaugurated on the other side. If infection is suspected, disinfection of cargo, baggage, and passengers should be carefully carried out. Persons sick, or supposed to have the disease incubating, should be detained till complete recovery, or till the expiration of the period of incubation. Apparatus is now in existence for turning voluminous streams of sulphurous acid or other disinfecting gases into all parts of vessels; these gases are then confined by the closing down of the hatches for some hours.

342. For preventing the spread, from any place in the interior, of an epidemic which has gained a foothold, similar precautions are taken. On the outbreak of a serious epidemic in any place, inspectors are appointed by governments in connection with their central health boards. Some of these inspectors may be stationed at the seat of the epidemic, and perform such inspections, and take such other measures as will have the least tendency to interfere with commerce and travel whilst securing immunity from infection. Others on board trains and boats perform the same duties as regards inspection, disinfection, detention, and vaccination, as are performed by the health and quarantine authorities in connection with ocean travel and commerce.

343. On railroad trains the dry-earth system should be introduced; otherwise cholera and typhoid germs may be distributed along the track and do harm, especially at stations. There is no knowing how

far they may be wafted with the dust blown up from the track. That cholera follows railroads is well known.

344. **An immense saving of money** is effected by these means, and this will be much greater when people more fully understand and rely upon the measures taken by health organizations to free commerce and travel from the risk of spreading disease. The saving to places which are so guarded that the disease does not take a foothold cannot be estimated. The much more important saving of life and the immunity from panic need only be mentioned; they will be readily understood and appreciated.

345. **In this Province the laws for the suppression of infectious diseases** have of late years been greatly improved and extended, and are most valuable if properly carried out by the municipalities, many of which have responded well to the calls that have been made upon them to protect themselves from disease.

346. **School teachers, trustees and health officers** should take, and are taking, increasing precautions to exclude contagious diseases from the schools, and to protect those committed to their charge from the dangers of infectious diseases. The principal measures to this end are the keeping of a record of the illnesses of absent scholars, watchfulness as to the existence of infectious diseases either amongst pupils themselves or in the households to which they belong; and the observance in regard to the latter of different rules in different diseases, according as the contagion produced by them may or may not be conveyed by persons not themselves affected. In these cases a certificate from the medical health officer or medical attendant should be required. Many of the School Boards are also aiding in the carrying out of the provisions of the Vaccination Act.

347. **The yearly diminution of the number of deaths** from infectious diseases, since 1881, must be a gratification to all who are engaged in this good work, and it is at the same time an encouragement to increased care and effort.

CHAPTER XI.

CLOTHING—PROPERTIES AND ACTION OF—MATERIALS—COLOR—SHAPE—SIZE—HEAD COVERINGS—BOOTS—DEFORMITIES OF THE FEET—INFANT CLOTHING.

348. By lessening radiation, and obstructing convection, of heat from the body, clothing conduces to the warmth of the latter. The heat radiated is absorbed by the clothing, and has to be again radiated from it; the clothing also retards the too free passage of currents of air, which would convey heat from the body. Hence, other things being equal, those substances which have feeble powers of radiation, which are impermeable, and which are poor conductors of heat, make the warmest clothing.

349. Clothing should, however, be somewhat permeable: of such a character as will allow of a free passage of the exhalations of the skin. Imperviousness, except during inclement weather for a limited period, may, by retaining the cutaneous excretions in contact with the body and preventing their oxidation, lead to disease.

350. The greater the hygroscopic powers of substances the warmer they will be. Evaporation produces cold: therefore, substances which part rapidly with their moisture allow of rapid cooling also—heat becoming latent.

351. Layers of air in clothing act as non-conductors. This is one reason why loose clothing is warmer than tight-fitting clothing; hence, too, several thin garments are better than one thick one of the same material.

352. Clothing acts also as a protection against too fierce heat radiated to the body. In this protection much depends on color. White is the best color, then gray, yellow, pink, blue, black. In hot countries, therefore, white or light gray colors should be selected. In the shade the effect of color is not marked.

353. Another point connected with color is the relative frequency with which soldiers in battle with differently colored clothing are

struck by bullets. Red is found to be the most fatal color, then green, brown and bluish gray. The proportions in the order named are 12, 7, 6 and 5.

354. The powers of absorbing odorous substances is of some interest, inasmuch as it is supposed by some that such substances also possess infective properties. Stark's observations demonstrate that this power is in the following descending scale:—black, blue, red, green, yellow and white. Texture is also largely concerned; wool, therefore, from its power of absorbing moisture, will retain odors the longest. Underclothing should be frequently changed.

355. Poisonous coloring materials, such as arsenic and anilines, sometimes give rise to serious trouble. Green and red are often poisonous. Underwear is better to be white; that it *shows* dirt is the reverse of an objection. It is a common error to suppose that red flannel has any superiority over white.

356. The materials of which clothing is made are cotton, linen, hemp, wool, silk, fur, leather, and India rubber. Cotton is more extensively used for clothing than any other substance belonging to the vegetable kingdom. It does not allow of such rapid evaporation as linen, nor is it so great a conductor of heat. In cold weather, therefore, or when it is desirable to avoid cooling, cotton or Canton flannel is to be preferred to linen for inner clothing. Hemp is rarely used in the present day, as its fibres are objectionably coarse and harsh.

Flax is converted into fabrics called linen; the fibres are finer than those of cotton. The applications of linen for clothing purposes are very numerous, possessing, as it does, several advantages over other materials, especially for inside garments. It absorbs the perspiration from the body with great readiness, and, consequently, allows of its free evaporation. It is an excellent conductor of caloric, and hence it is preferable to cotton for summer use, and is far more agreeable.

The finest wools have the smallest fibres. Woollen fabrics are bad conductors of heat, and readily absorb moisture. The water penetrates into the fibres themselves, distends them, and also lies between them. In this respect wool is greatly superior to either cotton or linen, its power of absorption being very much greater in proportion to its surface. During perspiration evaporation from

the surface of the body is necessary to reduce the heat which is generated, as for example, by exercise. When the exercise is finished the evaporation may still go on to such an extent as to chill the body. When dry woollen clothing is put on after exertion, the vapor is condensed in the wool; whereas the perspiration passes through cotton and linen, evaporates from the external surface, and the loss of heat continues. Woollen fabrics are also less easily penetrated by cold winds. Flannel underwear of varying thickness, according to the season of the year, is conducive to health. In very hot weather a thin belt of flannel may with comfort be substituted. Furs are very warm, partly owing to the layer of air kept in them, and are a good protection against extreme cold. Leather is only used for shoes, leggings and accoutrements. Silk is a good non-conductor of heat, and does not readily absorb moisture.

357. As a protection against cold winds, fur, leather and India rubber take the first rank, wool second, cotton and linen about equal. Owing to the condensation and retention of perspiration, the Council of Health of the French Army has persistently refused to allow the introduction of waterproof garments. This objection can only be considered valid when waterproof clothing is persistently worn.

358. Clothing should be evenly distributed over the surface of the body, so as to equalize the circulation. An extra flannel around the abdomen is sometimes an advantage. The exposure of the arms, legs, thighs and upper part of the chest in young children is very bad, especially in cold weather, or in the chilly evenings of summer time. The same remark holds good of the custom of ladies in cutting away their garments at the upper part of the chest: this is not only exposed in evening dress, but it has rarely more than the thin covering of the outside dress at any time, whilst immediately below are many thicknesses. Ball dresses, combined with the overheating of the dance and the subsequent chilling, are notoriously bad. Thin-soled boots err in the same way, by allowing the soles of the feet to be cold. They are also liable to permit too much moisture to reach the feet. Teachers and others should see that children do not sit in damp clothing.

359. The night-clothing of young children should be so made as to secure a warm covering to the whole body under all circumstances. Night coverings to the feet, however, sometimes tend to make them

throw off the clothing. The combined waist and drawers answer well.

360. The shape, size and pattern of clothing are of the utmost importance: the movements of the chest, abdomen and limbs should not be restrained by tight clothing, hence tight waistcoats, corsets, stays, coats and trousers are highly objectionable. Tight-lacing, as practised too frequently by girls, until the waist looks like an hour-glass, and as easy to snap as a pipe-stem, results in dangerous compression of all the vital organs (Fig. 45), and must, if perse-

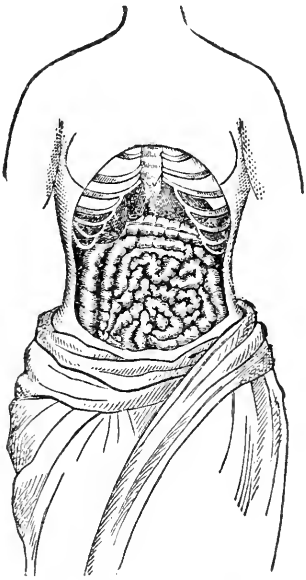


Fig. 44.—Positions of viscera in the natural waist.

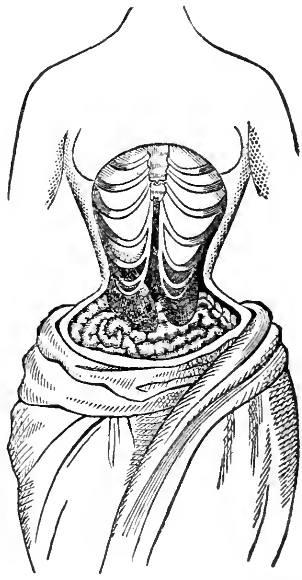


Fig. 45.—Positions of viscera in a waist deformed by tight-lacing.

vered in, end in disease and deformity. Tightness of any article of dress is particularly to be guarded against in children, in whom the bones are soft and easily bent out of their proper shape. Garters are apt to induce varicose veins, and also spoil the shape of the leg.

361. Clothing should not be heavy. Warmth should be obtained, not by adding great weight, but rather by thicknesses of loose material

which will hold layers of air, as for example, thick, loose woollens, and such materials as eider-down. This latter is especially suitable for night-coverings, to which the above remarks apply with great force. Great weight, even of bed-clothes, is very tiring, especially to young children.

362. The weight of clothes should not press unduly on parts which may be injured by such pressure. For example, the dragging of a woman's skirts upon her waist may give rise to disease of the abdominal organs. In male attire, the belting on of the trousers is also injurious.

363. Head covering.—Tight-fitting silk or beaver hats, made of substances which are non-conductors of heat, retain the heated air in contact with the head, and by compression frequently give rise to headaches. Frontal headaches and neuralgia in women are largely attributable to the want of covering for the forehead.

364. The neck should be either bare or with only a loose-fitting collar. A tight-fitting collar prevents the free circulation of the blood in its passage from and to the head. The liability to take cold is also increased, if at times the covering is dispensed with. In children, except in cold and damp weather, the neck should be left exposed.

365. The effects on the head and neck of the direct rays of the sun in very hot weather may in a great measure be prevented by the use of a suitable covering. A wet cloth folded and placed in the crown of the cap, and a similar wet cloth to the nape of the neck, will prove an excellent protection.

366. Boots and shoes, instead of allowing the same freedom to the toes as to the fingers, often cramp them together, and render them of little more value than if they were all in one; the joints become stiffened, enlarged and distorted, the toes often overlapping each other, to the extent of rendering them unfit for service (Figs. 46 and 47).

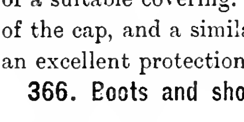


Fig. 46.—Distorted foot: dorsal surface.

367. The proper shape of the foot (Fig. 48) we shall find in the new-born; we shall also find it in persons accustomed to walk barefoot, and in families that have always been accustomed to have their children supplied with shoes of a correct form. In examining the impress of a well-shaped naked foot in the sand we shall find the

following marks: Behind we have the regularly rounded heel; in front the oblique impression of the soles of the toes. Between the sole of the great toe and heel the foot is elevated, and no impression is made. The form of the sole, then, is that of an arch, with the extremities enlarged; in front of the arch are the five oval impressions of the toes. In comparing the impress of the natural foot with the sole of an ordinary shoe, we shall perceive at once that the middle of the exterior border of the latter is out of the natural line; the sides of the great and little toe press against the upper of the shoe, and the heel is pressed on all sides by the stiff lining. The extremity of the great toe being thus pressed, the nail is forced into the flesh. The other toes become the seats of corns, bunions and chilblains, also of accumulated perspiration; the skin macerates and inflames, and mixing with the products of the sebaceous glands, an offensive odor is exhaled, and more or less ulceration may result in proportion to attention or neglect of very frequent washing. Another evil occasionally results, namely, the production of flat-footedness or splay foot.

Fig. 47.—Distorted foot: plantar surface.

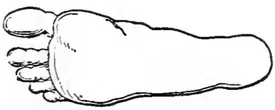


Fig. 48.—Natural shape of the foot.

368. In obtaining a properly made boot (Fig. 49), the principal points to be attended to are, that the sole shall be as broad as the foot when the weight of the body rests upon it. In the action of walking the foot expands in breadth and length,—in length often as much as $\frac{1}{10}$, in breadth even more. The shoemaker measures when the person is sitting, and, as a rule, allows only $\frac{1}{24}$ for increase. The heel should be made low and broad, so that the weight is not thrown on the toes, and that the muscles of the calf of the leg be permitted to act, which they cannot do well with a high-heeled boot. The inner line of the boot should be made straight, so as not to push outward the great toe. The hygiene of the foot should be attended to from infancy. The Indian moccasin is the easiest and most comfort-

Fig. 49.—Properly made boot.

able covering, as it adapts itself completely to the shape and motion of the foot.

369. Stockings should fulfil the same conditions. Dowie, a celebrated Scotch shoemaker, insists that tight-toed stockings are injurious to the feet, and recommends that they be woven with a separate covering for each toe, as gloves are made with fingers.

370. Infant clothing should be soft in texture, so as not to irritate the tender skin. It should be very loose, so as to give full play to all parts of the body, and be so simple as to admit of quick and easy adjustment.

371. Children should not be kept penned up, nor under restraint, for want of suitable clothing. They should have clothing which will keep them comfortable in cold and boisterous weather; and it should not be of such shape, size or material that they cannot, or may not be allowed to, romp about in it.

CHAPTER XII.

STRUCTURE OF THE SKIN—ITS FUNCTIONS—OBJECTS OF BATHING AND OF DIFFERENT KINDS OF BATHS—HINTS IN REGARD THERETO.

372. The skin is composed of two principal portions: (1) the epidermis or outer portion, named also the cuticle or scarf-skin; and (2) the derma, or inner portion, which is called the true skin. By maceration the layers of the skin may be separated, and their structure examined.

373. The epidermis is a cellular structure. The cells are arranged in strata or layers, and they differ in their characteristics. This difference leads to a division into two layers: (1) a superficial layer (*A* Fig. 50), and (2) a deep layer (*B*). Some physiologists make a further subdivision, four layers of the epidermis being distinguished by them. The epidermis is continually being reproduced from a stratum of plastic lymph poured out on the surface of the derma, or inner portion. First the deep layer of cells is formed; these are round or prismoidal and soft. They are constantly coming into existence, and pushing those above them outwards in the direction of the external surface: as the cells are forced out they gradually assume the flattened hard appearance of the superficial layer, which is thus composed of thin hard plates or scales, which become dry, and are finally detached and cast off as worn-out material. The deep layer is composed of soft round or prismoidal cells. Some of these contain *pigmentary deposit,* which gives to different races of people their different colors, a darker skin being characteristic of a greater abundance of deposit. The epidermis, then, is the product of the derma, which it serves to envelop, protect and defend. It also possesses the function of diminishing the evolution of heat and the amount of watery evaporation from the body.

374. The derma, or true skin, has numerous conical eminences or projections, called *papillæ* (*C*). These are abundantly supplied with small blood-vessels and nerves, and are highly sensitive. Where the

sense of touch is most acute there are found several irregular spiral coils of nerve filaments, associated with peculiar little bodies called "*tactile corpuscles,*" situated in the papillæ. In the pulps of the fingers these tactile corpuscles are most abundant. Papillæ are very numerous on the palmar surface of the hands and fingers, where a number of curved ridges and intermediate furrows may be seen. In these parallel curved ridges may be found double rows of papillæ. The intermediate furrows are the interspaces between pairs of papillæ in the ridges. There are also transverse furrows dividing the ridges into quadrangular parts. In the centre of each quadrangular part is situated a small orifice, which is the mouth of a sweat gland, or sudoriferous duct.

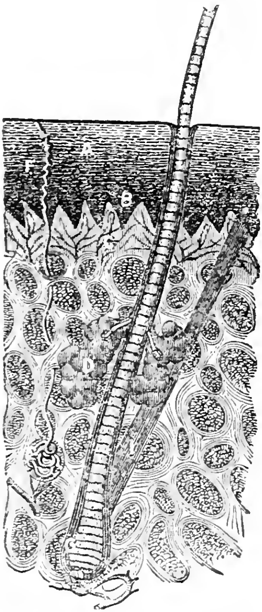


Fig. 50.—Section of skin: (*a*) superficial layer and (*b*) deep layer of the epidermis; (*c*) papillæ (of the derma); (*d*) sebaceous gland; (*e*) sudoriferous gland; (*f*) spiral termination of sweat duct; (*g*) hair bulb; (*x*) hair shaft; (*i*) muscle which erects the hair.

The nerves and arteries may be seen entering the skin through the areolæ in the deeper portions, to distribute themselves in the papillary, and other layers of the skin.

375. The sebaceous glands (*D*) are sacculated and contain an oily opaque secretion. They are situated most abundantly about the scalp, mouth, face, and ear. Each gland has a single duct which opens either at the cutaneous surface or into a hair follicle.

376. The sudoriferous glands, or sweat glands (*E*), are distributed over every portion of the surface of the body. They are more abundant in some parts than others, as on the palmar surface of the hands, where it is estimated that there are, in each square inch, about 3,528. The average number per square inch of the whole surface of the body is supposed to be about 2,800, and the total number about 7,000,000. These glands are tubular. One extremity is coiled up in the subcutaneous tissue; a straight duct leads from this convoluted portion to the spiral extremity (*F*) in the epidermis. It terminates on the surface of the skin in an opening or pore. The external opening is directed obliquely towards the surface. The lami-

nated structure of the external layer of the epidermis forms a sort of valve in the oblique termination of the tube.

377. **The hairs** and the nails are cells of the epidermis in a modified form. Hairs may, for convenience of description, be divided into a root or bulb (*G*), and shaft or stem (*X*). The shaft is cylindrical. The root or bulb of the hair is enclosed in a sheath called a follicle. This follicle is merely an involution of the epidermis. It extends through the derma into the corium, and sometimes it penetrates into the subcutaneous tissue, as in the case of large hairs. The process of the formation and growth of a hair from its follicle is similar to the formation of the cells of the epidermis from the surface of the papillary layer of the derma.

378. **The skin is not to be viewed as an independent tissue,** with functions for its own benefit, but as a portion of a general system, existing by its dependence upon the other parts, and also contributing its full share to the maintenance of the health of the whole body.

379. **In the process of growth and nutrition** constantly going on in the human body, certain nutritive elements are supplied. These are appropriated by the several tissues, and assimilated in accordance with the principles of vegetative life in the body. The animal functions are carried on at the expense of the vegetative life. The exercise of the functions of the brain, nervous system and muscles are essentially destructive to these organs. Every thought, sensation or muscular action necessarily involves a destruction of corresponding tissue. In this way there is a continual process of waste and repair. The various tissues are being re-formed, the worn-out material being disintegrated and thrown out.

380. **That there are organs set apart for getting rid of effete** or used-up material, the retention of which is not only injurious, but positively fatal to life, was incidentally mentioned when we treated of the blood. These organs are said to perform the function of excretion. We find that they are all mutually dependent on each other. Especially is this mutual relationship found to exist between the skin, lungs and kidneys. Waste products, such as various organic matters, carbonic acid, certain salts and water are carried off by them. The skin eliminates a comparatively small quantity of salts, a little carbonic acid, and a large quantity of water, in the form of perspiration. It

also excretes various acids of the fatty series, such as acetic, formic, butyric, etc. The greater part of the salts and urea, with an insignificant portion of the carbonic acid pass off by the kidneys. The action of the lungs has been fully described.

381. It is estimated that the maximum loss by the skin and lungs in the process of excretion is about 5 pounds in 24 hours, and the minimum loss about $1\frac{2}{3}$ pounds. It has been estimated that the lungs excrete about $\frac{7}{18}$ of this, and the skin about $\frac{11}{18}$. The fluid perspiration is said to consist of 1.81 per cent. of solids, two-thirds of which are organic substances. Whenever the excreting functions of the lungs, or the kidneys or liver are interfered with, the skin endeavors to perform in an imperfect manner the office of these organs. Thus in diseased conditions of the system various abnormal substances such as uric acid, lactic acid, bile, pigment, albumen, sugar are found in the perspiration ; urea in increased amount is sometimes eliminated by the skin when the kidneys are obstructed in their action.

382. Various medicines are thrown out by the skin and kidneys, when taken internally, such as alcohol, iodine, etc., and these may be detected by their odor, color, and other properties in the exhalations. There is good reason to believe that the skin exhales an increased amount of carbonic acid when the lungs imperfectly perform their function of aerating the blood.

383. The skin is the great heat regulator of the body. When the general heat of the body is increased by muscular exercise, the circulation of blood on the surface is also increased. The superficial vessels are then, by virtue of their elasticity, dilated to receive the additional supply of blood and the excretion of the skin is thus increased. By this means heat is expended by the skin, and the temperature of the body prevented from rising above a healthy standard. Exhalation from the skin takes place in the form of sensible and insensible perspiration. The dog, and such animals as do not exhale freely by the skin, cool the body by increased respiration.

384. The skin is extremely sensitive to surrounding conditions of the atmosphere, by reason of the rich network of nerves and minute blood vessels in the papillary layer of the derma. The epidermis acts as a protective covering, and modifies this sensitiveness. The vast excreting apparatus, in the form of millions of little glands over the

whole surface of the skin, enables the body to either expend or retain heat, as circumstances may require. Heat is constantly being generated within the body by muscular action, mental exercise, and all the busy activities in the various tissues and organs of the body. Thus evolved it is constantly being carried by the blood to the tissues or organs, where it is again lost by radiation, conduction or evaporation. In this way the temperature of the body in health is equalized and maintained at a constant, uniform degree.

385. **Thus the body is enabled to protect itself** against the injurious effects of exposure to extremes of temperature. Under the influence of external cold the cutaneous vessels are constricted, and the blood is thus withdrawn from the colder and cooling parts to the warmer portions of the body. By this means less heat is expended by the skin, and the body retains sufficient heat to preserve a healthy temperature. Under the influence of an external warm atmosphere, on the other hand, the cutaneous vessels are dilated, the body perspires freely, the perspiration is rapidly evaporated, evaporation cools the surface, and the temperature remains at a healthy standard, even in an excessively hot atmosphere.

386. **The high degree of heat which can be borne** by the human body is incredible to one who has not considered the subject. Sir Thomas Watson thus relates the first discovery, by accident, of the truth on this subject: "In the years 1760 and 1761, MM. Duhamel and Tillet were appointed to devise some means of destroying an insect which consumed the grain in the Province of Angoumais in France. They found that this could be done by subjecting the corn, and the insects contained in it, in an oven, to a degree of heat great enough to kill the insect but not so great as to hurt the grain. In order to ascertain the precise heat of the oven, they introduced into it a thermometer placed upon the end of a long shovel. The mercury, when the thermometer was withdrawn, was found to indicate a degree of heat considerably above that of boiling water. But M. Tillet was aware that the thermometer had sunk several degrees as it was drawn towards the mouth of the oven. While he was puzzled to invent some way of determining more exactly the actual degree of heat, a girl, who was one of the attendants on the oven, offered to go in and to mark with a pencil the height at which the mercury stood. And

she did enter the oven and remained there two or three minutes, and then marked the thermometer at 100° of Reamur, which is nearly equal to 260° Fahrenheit. M. Tillet then began to expréss some anxiety for the safety of the girl, but she assured him that she felt no inconvenience and stayed in the oven ten minutes longer, during which time the mercury reached the degree of 288 Fahrenheit's scale, denoting 76° of heat above that of water when it boils. When she came out her complexion was considerably heightened, but her respiration was by no means quick or laborious." This experiment has been repeated by several persons since that time without serious results. For a short time this high degree of temperature can be borne. A temperature of 325° has been borne, and it is related of Chabert, the "Fire King," that he was in the habit of entering an oven whose temperature was 400° to 600°.

387. On the other hand, the degree of cold endured by Arctic voyagers appears equally remarkable. It has been recorded that a temperature ranging from 55° to 102° below freezing point has been endured in these cases with the exercise of proper precautions.

388. Extremes of temperature can be endured with impunity under some circumstances, but there are certain other conditions under which they produce injurious results. (See Chap. VII.)

The activity of the skin and the amount of perspiration is influenced by the nature and quantity of the food eaten, by the amount of fluid drunk, by the amount of exercise taken, also by mental conditions, and the relative activity of other secreting organs, more especially the kidneys. The condition of the surrounding atmosphere also has a marked influence on the functions of the skin.

389. After long-continued physical exercise, during which a considerable amount of heat has been evolved by muscular activity, the body naturally undergoes a cooling process. The energy of the body has in such a case been expended in heat, and therefore the power of resistance to the depressing effects of cold is lessened. An illustration of this is sometimes seen in the case of a man who, after a hard day's work in hot weather, exposes his body while in a state of rest or sleep, to copious draughts of cool air. The surface of the body is rapidly cooled, a great amount of heat is expended, and the blood is driven to the internal parts of the body to such a degree as to seriously

interfere with their natural condition. Frequently under these circumstances inflammation of some of the vital organs of the body ensues, and the ultimate results are dangerous, or even fatal to life.

390. **Any debilitating causes render the body less able to resist sudden changes** of temperature: such are excessive evacuations, a night's debauch, other excesses, long-continued loss of rest, any exertion, either physical or mental, by which there is a great loss or expenditure of energy. During rest or sleep the body is less able to resist exposure to cold. While taking active exercise, even though the clothes or the feet are wet, there is little danger of injurious effects. But immediately upon ceasing exercise and before resting, the clothes should be changed, the skin dried, and any further exposure avoided.

391. **Frequently it occurs that a man in a helpless state of intoxication** lies down on the damp ground, exposed to a cool damp wind, and indulges in sleep: the body is unable to resist external cold, owing to the depression and loss of heat resulting from previous excessive stimulation, and death results. The same individual in vigorous health, and not having been exhausted by previous excesses, might possibly have endured this exposure and lived.

392. **After the body has become habituated to a high degree** of heat it is more susceptible of injurious effects from sudden changes of temperature, especially after exercise. Those who are in the habit of living in very hot rooms are in this way more liable to repeated attacks of colds immediately upon exposure to such changes.

393. **The general principle with regard to sudden changes of temperature** laid down by Parkes, is that the greatest influence "appears to occur when the state of the body coincides with or favors their action. Thus the sudden checking of the profuse perspiration by a cold wind produces catarrhs, inflammations and neuralgia." Beyond this it is difficult to deduce from practical experience any reliable physiological law or principle with regard to the effects of such changes, under varying conditions of the body and surrounding circumstances.

394. **The skin should be kept free from obstruction,** in order that it may perform its functions in a healthy manner. The natural excretions if allowed to remain on the skin tend to obstruct the free, open extremities of the sebaceous and sweat glands, and thus the exhala-

tions are retained in the superficial vessels and returned again to the general current of blood.

395. The presence in the blood of effete material which should be thrown out is felt by the blood corpuscles—their vitality and functions are seriously impaired, and, as a result, nutrition is interfered with; what is called "blood poisoning" takes place if the balance of health is not restored. Nature, in order to provide a remedy, endeavors to eject this morbid material from the system through some other excretory organ, as the kidneys, lungs or liver.

396. Any organ thus performing the work which should be done by another is said to be "out of order," or to be suffering from functional derangement. This disordered function can easily be remedied provided the organ is in a healthy condition as far as its own organic structure is concerned. But after functional derangement has existed for a long time, organic structure suffers a deterioration, and what is called organic disease sets in. This is more serious, and most frequently defies all efforts at remedy.

397. Judicious bathing increases the activity of the functions of the skin, improves its nutrition, and assists in promoting the tone or strength of the vascular system. In this way it assists the body in resisting the injurious influences of sudden changes of temperature and other varying external conditions. Health is not only maintained, but also improved in cases where constitutional or acquired defects exist. Many diseases, such as rheumatism, erysipelas, bronchitis and ordinary colds, are prevented, and a vigorous health and longevity are promoted by judicious and systematic bathing. In some trades poisonous materials adhere to the skin, and require a frequent use of the bath (see Sec. 59). The following temperatures have been assigned to various kinds of baths:—

Cold Bath	33°	to	75°	Fahr.
Temperate	75°	"	82°	"
Tepid	82°	"	90°	"
Warm	90°	"	98°	"
Hot	98°	"	112°	"

398. Bathing in very cold water is attended with risk in the case of old persons and young children, or those whose systems are enfeebled by disease or any other cause But for those who enjoy good health

no more invigorating tonic can be used than the cold bath with friction of the skin. The proper degree of temperature must be regulated to suit the sensitiveness or vigor of the individual. During the bath the skin should be well rubbed, and as soon as the least chilliness is experienced it is prudent to withdraw. From five to fifteen minutes is quite long enough to remain in the water.

399. It is most important that reaction should be complete, in order to obtain the full benefit to be derived from a cold bath. When reaction has fully set in, the circulation in the skin becomes more rapid and a glow appears all over the surface. This causes an agreeable sensation of warmth in the skin, and the whole body feels refreshed and invigorated. Rest may now be enjoyed and food taken. If reaction has not fully set in, a brisk walk in the open air while warmly clad will aid in securing it. Warm sunshine also assists.

400. The temperature of the body is higher in the morning after waking in temperate climates, and it reaches its lowest point about midnight. While the temperature is at its maximum a cold bath is most agreeable. In tropical climates the minimum temperature is in the early morning, and the highest at mid-day.

401. Active exercise raises the temperature, and therefore exercise before a cold bath is beneficial. A cold bath should not be taken after long sustained physical or mental exertion, nor immediately after a meal, nor after exposure to cold, because at these times the temperature of the body is lower and reaction is not likely to be so fully accomplished. It is best not to take a cold bath sooner than three or four hours after a meal.

402. In hot weather, the noon bath, before eating, and after moderate exercise, is most beneficial, as the maximum temperature of the body is reached at mid-day during a continuance of such weather, especially if much exercise has been taken.

403. Sponging the surface of the body with cold soft water, to which has been added a little spirit or liquid ammonia, will serve a good purpose, when it is not convenient to have a cold bath. This should also be followed immediately by friction with a rough, coarse towel, until complete reaction has been effected. The cold sponge-bath may be taken in this way with advantage immediately after rising in the

morning. A little water in a basin or in an ordinary bath-tub is sufficient for this bath.

404. **When the body is warm and unexhausted** the re-active power is greatest. Under these circumstances application of cold water first drives the blood to the interior; but, with the aid of vigorous friction of the surface, it is repelled with sufficient force to fill all the superficial vessels, and thus re-action is accomplished. In order that this may take place, the health and vigor of the body should be sufficient to give natural tone to the arterial system. One who is perfectly healthy may without danger enter a cold-water bath after a hot-air bath. It is said, upon good authority, that, while the body is warm, a plunge into cold water is less dangerous than when it has cooled after having been warmed by active exercise.

405. **The warm bath** is preferable for cleansing the skin. By its use the skin is rendered softer and the tissues are relaxed. The length of time for remaining in the bath may be extended from twenty minutes to some hours without any other unpleasant results than a feeling of depression. Immediately after immersion an agreeable feeling of excitation is experienced, and the pulse is slightly accelerated; sometimes this is followed by a feeling of languor. The warm bath has a soothing, calming effect; if a person remains in it for a length of time a depressing influence ensues. As a means of invigorating the body, it is inferior to the cold or cool bath. It is principally used when the body is exhausted from excessive exertion, or for the purpose of removing from the skin impurities, such as epidermal scales, and oily or saline matters, or for procuring rest and soothing. By means of the warm bath the blood is encouraged to flow towards the surface and away from internal organs. Care should be exercised when coming out of a very warm bath that no sensation of chilliness is experienced. Friction with a rough towel should be practised, as in the case of the cold bath.

406. **By shower-baths** we can obtain, with a less expenditure of time and trouble, and with small quantities of water, many of the advantages to be derived from the various kinds of baths already described.

CHAPTER XIII.

FOODS—THEIR PURPOSES AND CLASSIFICATION—DIETARIES—PREPARATION OF FOOD—IMPURITIES AND ADULTERATIONS—THEIR RESULTS AND DETECTION.

407. There is a perpetual drain upon the blood to replace the matter lost by cutaneous and pulmonary transpiration, and by the other secretions and excretions which are wholly or in part eliminated from the body. To supply this waste there is elaborated from the food a fluid which, in essential qualities, nearly resembles the blood; this fluid is absorbed and poured into the veins, where it mixes with the blood, and in a short time ceases to be distinguishable.

408. There are certain elements necessary for the support of our bodies, such as carbon, hydrogen, oxygen, nitrogen, sulphur, potassium, chlorine and sodium. There are also other elements sometimes found in the human body, but these are the principal. They exist in combinations of certain proportions one with another in different parts of the body.

409. Albumen, a compound existing in the blood, is composed of carbon, oxygen, hydrogen, nitrogen, and sulphur in small proportion. It is a most important constituent, being the material from which many of the animal tissues are formed.

410. Fibrine, another compound, existing in an unformed state in the blood, is composed of the same elements as albumen. It is the substance out of which the blood clot is formed when an artery is accidentally cut, and bleeding threatens to destroy life: hence it is an important compound, without which our lives might be sacrificed by the slightest accident.

411. Other organic compounds made up of the simple elements mentioned above exist in the muscles, nerves, glandular, and other tissues. In the tissues are also found, dissolved in water, various mineral salts, such as sodium chloride, composed of chlorine, oxygen and sodium;

potassium chloride found in the muscles, blood, liver, etc.; phosphate of lime, found in the bones, teeth, and hair in a solid state, and in the blood in a liquid state.

412. Hydrogen and oxygen united in proportions to form water may be found in large quantities in all the tissues, fluids and organs of the body. It is one of the most important constituents, and exists in various forms. In muscle it is in combination with the muscular tissue. In other parts it is combined with fluids or partial solids. In the lungs it exists also in a vaporous state.

413. All these principal elements must be furnished in sufficient quantities to form the various compounds found in the body in a state of health, in order that all its parts may be properly nourished and maintained in their integrity. If one element necessary to form a compound is absent, the combination cannot be effected, though all the remaining elements are present.

414. The body also requires material to produce force and heat in its several parts. There is an expenditure of energy or force, and of heat, in the movements of respiration and speech, in locomotion, in all kinds of labor and muscular work, and in all the manifestations of nerve or brain.

415. Foods may be classified into five divisions. 1st. The nitrogenous: such aliments as muscle-fibrine, blood-fibrine, albumen and casein (in their animal and vegetable forms), and the vegetable compounds, glutin and legumin. 2nd. The hydro-carbons, or fats. 3rd. Carbo-hydrates: starchy and saccharine substances. 4th. Inorganic substances: water and salts—combinations of sodium, magnesium, calcium, potassium and iron, with chlorine and phosphoric acid. 5th. Accessory substances, which, strictly speaking, are not foods—such as fermented liquors, coffee, tea, spices, some of which are of service either as promoters of digestion or by retarding the too rapid waste of tissue. The hydro-carbons and carbo-hydrates contain carbon, hydrogen and oxygen; the nitrogenous foods also contain these elements, and in addition nitrogen, and generally sulphur and phosphorus. The carbo-hydrates contain hydrogen and oxygen in the proportions to form water, so that carbon is the only unoxidized element that is free to undergo oxidation.

416. To determine the ultimate uses of these classes of foods many

experiments have been tried with man and the lower animals. Much has been learned and many points still remain to be solved. The following conclusions have, however, been arrived at: that the nitrogenous foods are principally concerned in forming the various tissues, the active agents in life, but they may also contribute substances for conversion into heat and energy; that the hydro-carbons are pre-eminently calorifacient substances,—contributing material to be used up in the production of heat and energy,—but that they may also assist in tissue formation; that the carbo-hydrates are also calorifacients, and aid in the formation of fatty tissue. When a greater quantity of fatty or heat-producing food is supplied than is required for immediate use, it is withdrawn from the blood and deposited in some part of the body for future use. In this way no disturbance of the general system occurs, and a supply is stored away to be drawn upon when required. There is always a layer of fat deposited beneath the skin, and being a bad conductor of heat, it contributes towards retaining the animal warmth in the body.

417. "**The nitrogenous, albuminous or proteine compounds** comprise albumen, fibrine, caseine and certain other bodies which form modifications of these."—(Pavy.) These three principal forms of nitrogenous foods are found in abundance both in plants and animals. The flesh of animals, the white of eggs, and the albumen stored in nuts and other seeds of plants, are typical examples. In plants albuminous compounds exist, which are in their component parts very similar to albumen found in animal structures—fibrine also is found in vegetables often associated with albumen. Of the vegetables used as food, beans and peas contain the largest amount of nitrogenous matter.

418. **Hydro-carbons, or fats,** are met with both in the animal and vegetable kingdoms, both in liquid and solid forms. In the hybernating animals the great accumulation of fat which takes place during autumn is largely due to the oily nature of the nuts, seeds, etc., which they use at that time as food.

419. **Carbo-hydrates consist of starch, sugar and gum,** obtained principally from the vegetable kingdom; from their easy digestibility they are in many cases preferable to fats. It is only after conversion into grape-sugar, by the action of the digestive processes, that they

are utilized in the system. In disordered conditions of the stomach sugar should not be taken largely, as it is apt to undergo fermentation, and produce acid gas.

420. Inorganic aliments.—Salt is directly useful in facilitating digestion. Phosphate of lime and carbonate of lime constitute two-thirds of the weight of the bone tissue. The phosphate occurs in bones in larger quantity than the carbonate, the proportion being about fifty-seven parts of phosphate to eight of carbonate. Wheat, rye, corn and barley contain phosphates in considerable quantities. Iron, although it only exists in small quantities, plays an important part in the blood corpuscles and in the coloring matter of muscle.

421. The forms in which water exists in the body have been described (Sec. 412.) As a food it acts as a solvent and vehicle to other matters, and is largely utilized in the excretions from the skin, kidneys and lungs. It exists uncombined in the various kinds of fruits and vegetables, which contain from seventy-five to ninety per cent. of it. The various inorganic elements derived by plants from the soil are carried to the leaves and other parts by the water thus abundantly supplied to the plant.

422. Of the fact that a mixed diet is not only acceptable, but necessary, evidence is furnished from several sources: (1) from instinctive proclivities, (2) from the comparative anatomy of the organs of digestion, (3) from experiments and experience, (4) from comparisons of the composition of such substances as bread and meat, with the amounts of carbon and nitrogen daily excreted by the lungs, skin, kidneys and bowels: to obtain a proper amount of nitrogen a quantity of bread must be consumed containing double the amount of carbon required; and of meat five times more must be consumed to supply the carbon than is necessary to furnish the nitrogen. In proportion to the increase of fatty and saccharine matter, the supply of bread may be diminished. Change in the combinations in which food is presented is also very beneficial.

423. Dietaries should be constructed so as to allow of a due admixture of animal and vegetable food containing substances belonging to all the classes previously mentioned. Even this is not enough: the articles must be varied at times, or functional derangement and disease may occur.

424. The necessary quantity of food per diem is in some measure modified by the age, sex and amount of exercise taken. The following table we have compiled from the recorded figures of a number of observers :—

The amounts of the undermentioned substances are calculated as "water-free," the water, (50 to 60 per cent.), naturally co-existing with them having been separated from them. This addition must be made in supplying the actual food.	Subsistence diet, *i.e.*, to maintain a man's* body unimpaired when kept from exertion : average of all the authorities quoted by Pavy and Parkes.	Diet for a man* in comparative idleness ; general average from all the authorities quoted by Pavy and Parkes.	Diet for a man* at ordinary work ; general average of all the authorities quoted by Pavy and Parkes.	Diet for a man* at ordinary work : according to Moleschott.	Diet for a man* at ordinary work : according to Petenkoffer and Voit.	Diet for a man* at ordinary work : according to Ranke.	Diet for a man* at very hard work : average of all the authorities quoted by Pavy and Parkes	Avoirdupois ounces of foods for each pound of body weight of a man according to subsistence diet. (Parkes.)†	Avoirdupois ounces of foods for each pound of body weight of a man according to diet for ordinary work. (Parkes.)†
	oz. avoir.	oz. avoir.	oz. avoir.	oz. avoir.	oz. avoir.	oz. avoir.	oz. avoir.		
Nitrogenous matter........	2.16	3.35	4.86	4.59	4.83	3.52	6.21	.017	.031
Fats	0.67	1.15	2.97	2.96	4.12	3.52	3.44	.007	.019
Carbo-hydrates	11.84	15.3	14.81	14.26	12.40	8.46	18.13	.080	.095
Mineral substances........	0.5	0.6	1.19	1.06	1.06	0.89	1.3	.003	.007
Total food............	15.17	20.40	23.83	22.87	22.41	16.39	29.08	.107	.152

During infancy and childhood more food is eaten in proportion to the size of the body than in adult age, and more is required, in consequence of the development of tissue which is taking place.

The kind of work in which people are engaged must also be considered : brain workers require more phosphorus than those whose work does not require much thought. The athlete in training requires much nitrogenous food.

* A man of average height and weight (say 150 lbs.)

† In children the proportionate amount would be rather more.

425. Climate has also to be considered. The amount of food taken in warm climates is, as a rule, less than that taken in cold ones. The East Indian lives on a little rice, while the Greenlander eats several pounds of fat meat daily, washing it down with train oil. The inhabitants of Arctic regions appear to have a natural relish for the oleaginous or fatty foods with which nature has provided them in the seals, whales, and other animals in these regions. It has also been asserted by travellers in extreme northern latitudes, that they experienced a positive craving for fats, although while previously residing in warmer climates they lived principally on fruits and vegetables, which contain large proportions of water and smaller proportions of heat-producing material, the latter in the more suitable form of carbo-hydrates. The fruits and vegetables commonly used in hot countries contain from eight to twelve per cent. of heat-producing matter, or carbo-hydrates, while the fats and oils used by inhabitants of northern climates contain from sixty-six to eighty per cent of carbon.

426. From the vegetable world comes, directly or indirectly, the principal part of the food of man. Plants, under the influence of solar light and heat, have the power of taking out of the earth and surrounding air certain elements and constructing compound substances suitable for the support of animal life. In this way plant life is constantly engaged in supplying food for animal life. Some animals live on vegetable food alone; some on animal food alone; others, again, on both vegetable and animal food. When animal food is used it contains organic compounds which were derived from vegetables or plants, and thus, too, plant life is indirectly the source of animal food.

427. The amounts of the various nutritive principles contained in articles of food must be known in order to provide the relative proportions most conducive to the healthy maintenance of the body. On the next page will be found the percentage composition of a number of the most common articles taken from a table furnished by Letheby, with additions (marked *a*) from one furnished by Parkes.* We have added to the table a few articles (marked *c*) which are in common use in Canada, and of which the analysis is given separately by Dr. Pavy.

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* From a Treatise on Food and Dietetics, by F. W. Pavy, M.D., F.R.S., Wood's Library of 1881 p. 291.

ARTICLES OF FOOD.	Water.	Albumen, etc.	Starch, etc.	Sugar.	Fat.	Salts.
Bread	37	8.1	47.4	3.6	1.6	2.3
Biscuit (*a*)	8	15.6	—73.4—		1.3	1.7
Wheat flour	15	10.8	66.3	4.2	2.0	1.7
Oatmeal	15	12.6	58.4	5.4	5.6	3.0
Indian corn meal	14	11.1	64.7	0.4	8.1	1.7
Buckwheat (*c*)	13	13.1	—68.4—		3.0	2.5
Rice	13	6.3	79.1	0.4	0.7	0.5
Peas (dry)	15	23.0	55.4	2.0	2.1	2.5
Beans (French) (*c*)	9.9	25.5	—58.6—		2.8	3.2
Arrow-root	18	..	82.0	..	..	..
Potatoes	75	2.1	18.8	3.2	0.2	0.7
Carrots	83	1.3	8.4	6.1	0.2	1.0
Parsnips	82	1.1	9.6	5.8	0.5	1.0
Turnips	91	1.2	5.1	2.1	..	0.6
Cabbage	91	2.0	—5.8—		0.5	0.7
Sugar	5	..	..	95.0	..	..
Treacle	23	..	..	77.0	..	..
New milk	86	4.1	..	5.2	3.9	0.8
Cream	66	2.7	..	2.8	26.7	1.8
Mushrooms (*c*)	91	4.7	—3.45—		0.4	0.45
Skim milk	88	4.0	..	5.4	1.8	0.8
Buttermilk	88	4.1	..	6.4	0.7	0.8
Cheese (*a*)	36.8	33.5	..	.	24.3	5.4
Lean beef	72	19.3	..	..	3.6	5.1
Fat beef	51	14.8	..	..	29.8	4.4
Lean mutton	72	18.3	..	..	4.9	4.8
Fat mutton	53	12.4	..	..	31.1	3.5
Veal	63	16.5	..	..	15.8	4.7
Fat pork	39	9.8	..	..	48.9	2.3
Green bacon	24	7.1	..	..	66.8	2.1
Dried bacon	15	8.8	..	..	73.3	2.9
Ox liver	74	18.9	..	..	4.1	3.0
Cooked meat, roast, no dripping being lost. Boiled, assumed to be the same (*a*)	54	27.6	..	..	15.45	2.95
Poultry	74	21.0	..	..	3.8	1.2
White fish	78	18.1	..	..	2.9	1.0
Oysters (*c*)	80.4	14.0	..	..	1.5	2.7
White of egg	78	20.4	..	..	..	1.6
Yolk of egg	52	16.0	..	..	30.7	1.3
Butter and fats	15	..	..	..	83.0	2.0
Beer and porter	91	0.1	..	8.7	..	0.2

423. Wheat owes to the gluten which it contains its aptitude to be made into bread. In all the farinaceous seeds (such as wheat, oats, barley and corn), albumen, gluten and casein exist in large propor-

tions. From one to over three per cent. of mineral bone-forming matter is also contained in all these cerealia.

429. **Biscuits, cheese and dried leguminous foods** such as peas and beans will be found to contain a large amount of nitrogenous principles, a fact of some importance under circumstances which render it difficult to procure flesh meat. It is one of the facts which accounts for the maintenance of vigor, notwithstanding the deprivations endured, by the recent military expedition in the North-west territories of Canada.

430. **That milk contains all the necessary elements,** and in proportions approaching those in the dietaries given on page 158, will be seen from the foregoing table. The dry constituents of a pint of pure cow's milk are about as follows: nitrogenous matter (casein) 369 grains; fatty matter, 351 grains; lactine, in the form of sugar, 486 grains; mineral matter, 72 grains. Thus, a pint of milk equals a mutton chop. Cow's milk contains too much casein, and if diluted, too little fat and sugar, for very young infants. The best substitute, therefore, for breast milk would be two parts of cream, one of milk, and three of a solution of sugar of milk of the strength of two ounces to a pint of water. The substitution of barley water for water alone, is considered by some to be of good service in rendering the milk curd more digestible. The proper quantity of such milk for an infant is two to three ounces every two hours. If there should be too much acidity to digest it, a little lime water may be given.

431. **The digestibility of the various articles** must not be lost sight of in the consideration of dietaries; and with this, age, modes of life and climate have much to do. Individual peculiarities too have a strong modifying influence. Hard and cohesive articles are, as a rule, difficult of digestion. Experience is the best guide in this matter. Articles are more digestible when fresh; we must except fresh bread and recently killed meat.

432. **Modes of cooking** greatly modify the nutritive properties of food. In boiling meat the loss of weight is about twenty to thirty per cent. To retain the salts and soluble substances in the meat the piece should be left large, placed in boiling water for a few minutes, to coagulate the albumen, and then cooked at a lower temperature. To make good broth the meat should be cut small, put into cold water,

and then warmed to a temperature of 150°. There is not the amount of nutriment that is commonly supposed in broths obtained by the action of heated water.

433. Broth may be made without heat by the addition of four drops of muriatic acid to a pint of water and half a pound of beef. Such broth is richer in soluble albumen. If rather more muriatic acid be used, but no salt, a heat of 130° Fahr. may be applied.

434. In roasting, the loss varies from twenty to thirty-five per cent. To retain the juices the meat must be first subjected to intense heat, and afterwards cooked slowly.

435. Beverages such as milk, tea, coffee, chocolate and cocoa have of late years superseded beer and wine to a great extent as ordinary drinks at meals. In hot weather, lime or lemon juice forms, with sweetened water, not only an agreeable drink, but, taken daily on long voyages, when fresh foods are scarce, it is an excellent preventive of scurvy. Farinaceous drinks, such as oatmeal-water mixed in the proportion of three or four ounces of oatmeal to the gallon of water, are very refreshing for persons engaged in the harvest-field, or otherwise exposed to heat and fatigue.

436. Condiments are substances which give piquancy and flavor to food, stimulating the salivary glands and stomach.

437. Diseases connected with food may result from excess, impurity or deficiency of it, or to a disproportion of the various nutritive principles. Excess will lead to constipation or to irritation, resulting in diarrhœa, fœtor of breath and dyspepsia. When albuminates pass into the system in excess, congestions and enlargement of the liver, and a general state of plethora, with fatty degeneration of the heart, may ensue; and when but little exercise is taken they may give rise to gout. In the endeavor to prevent these results the kidneys throw off a large amount of urea and urates. Excess of starches and fats delays metamorphosis of nitrogenous tissues and produces too much fat, particularly if the drinking of large quantities of fluid, such as beer, is indulged in. The success of Mr. Banting's treatment of obesity is principally owing to the lessened interference with the oxidation of fat consequent on the entire deprivation of sugar and starches.

In starvation, or deficiency of food, the tissues of the body are consumed for the production of heat and energy, and their place not

being supplied, rapid loss of weight is the consequence. Typhus fever, scurvy, and anæmia or bloodlessness, are some of the consequences.

438. Diseases often arise from altered quality of meat, such, for example, as may be caused by epidemic pleuro-pneumonia, foot-and-mouth disease, carbuncular fever, rinderpest, braxy (in sheep), trichinæ and other parasites. There is a very great discrepancy of evidence to be found in the statements made from 1737 down to the present time regarding diseases presumed to have arisen from the use of the meat of diseased animals, and the difference of opinion is so great as to lead to the conclusion that the stage of the disease, or the part eaten, or the mode of cooking must have great influence, and that more study than has yet been given to this subject is necessary to clear up the great varieties of statement. The flesh of overdriven animals is said to be unwholesome. Much doubt exists as to the effects of epidemic pleuro-pneumonia on meat. Kaffirs have been known to eat, without injury, the meat of cattle destroyed by this disease. The apparent increase in the number of cases of malignant pustule in men has been ascribed to the eating of the flesh of animals suffering from it, but it is quite likely that inoculation may have taken place in other ways. The same remarks apply to the meat of cattle or sheep which have died from splenic apoplexy, from braxy, from rinderpest, and from foot-and-mouth disease. On general principles we must conclude that the tendency of all diseases is to deteriorate the flesh, and it is of great importance to have the animals as healthy as possible.

439. Meat partially decomposed or tainted is liable to produce disagreeable and dangerous results. Sausages and pork pies sometimes become poisonous from the formation of a substance, perhaps fatty, the exact nature of which is as yet unknown.

440. Tuberculosis.—Observations of numerous German and English physicians have definitely established the fact that raw tuberculous matter taken from man and animals and eaten by other animals may produce tuberculosis in the latter; that the milk of tuberculous animals will at times produce consumption in susceptible subjects, especially when the morbid deposit has taken place in the udder; and that tuberculosis is very common amongst cows fed on distillery wash, especially if they are kept in warm or crowded stables. Although robust individuals may withstand the influence of tubercle taken into the stomach,

it must be otherwise with the weak and young, those with poor feeding and bad air, living in damp, sunless localities, and subjected to much exposure.

441. **The victims of trichinosis** are persons who eat raw meat highly seasoned, instead of being cooked. This is most common among Germans. The disease is one in some measure resembling typhoid fever, but attended with intense pains in the limbs. It is caused by a parasite which works its way through the muscular tissues, burrowing in them, and enclosing itself in a capsule. A temperature of 144° to 155° Fahr. will kill the trichinæ that have escaped from their capsules and are wandering through the muscular substance, but the encapsuled are considered to require a much higher temperature. As a practical rule it may be said, that if any of the blood-red color of meat is retained, there is still danger, and the meat should for a time be subjected to a heat of 212°.

442. **Amongst other parasites** originating from meat are the pork tape-worm (*taenia solium*), the beef tape-worm (*taenia mediocanellata*), the hydatid tape-worm (*taenia echinococcus*), the various flukes, such as the liver fluke (*distoma hepaticum*), and the more rare forms, the *ancylostomum** and the *leptodera teres*, the attacks of which are similar to those of the trichina. The larvæ of many of these parasites infest the flesh of animals used for food. Such meat is commonly called "measly," the "measles" being the little cysts or capsules containing the larvæ. Parasites are also found in fish, but it is very rarely that they give rise to disease in man. Some of the above forms, as well as others, such as the *ascarides*, (a variety of intestinal worms), may be taken into the system with vegetable food and water. Thorough cooking will render them harmless. But any meat known to contain parasites should be condemned. A disease called *actinomycosis*, common to men and cattle, has recently occurred in one of the neighboring States, as well as in Germany. It is caused originally by a vegetable growth, and attacks the teeth and jaws: in the latter case it is fatal in man.†

443. **In determining the character of meat** the following points should

* A Lecture on Parasites, by L. S. Cobbold, M.D., F.R.S., may be found in the London Health Exhibition Literature, 1884, Vol. XII.

† "'Swell-head' in Cattle," by W. T. Belfield, M.D. Transactions of the American Public Health Association, Vol. IX., pp. 111-115.

be noted: it should be "firm and elastic to touch; marbled appearance." The color of the flesh should be a healthy red: if it is purple it may indicate some congestive or febrile disease, or that it has not been bled, but has died of disease. The odor should not be putrid nor alkaline. If the meat contains cysts or parasites, they may sometimes be seen with the naked eye; but they are more likely to be detected by the microscope. The brain and liver should be examined for hydatids, the lungs for abscesses, especially during the prevalence of pleuro-pneumonia, and the alimentary canal for cattle plague. Bites on game and poultry are sometimes inflicted by rabid dogs and foxes.

444. Certain kinds of fish and shell-fish may occasionally produce poisonous symptoms, where there is no evidence of the animal being diseased. Severe irritation of the stomach, bowels and skin and loss of nerve power have resulted. Fish should be firm and free from alkaline odor; their gills should be red and firm if they are fresh. Salt fish is far inferior to fresh fish in nutritive value and wholesomeness.

445. Canned foods are sometimes injurious from putridity. In this case the ends of the cans are apt to bulge. In good cans the outer surfaces of the ends are likely to be somewhat concave, owing to condensation after the hot contents have been sealed up and become cool. Metallic poisoning may occur, owing to the cans being made of bad material or to carelessness in sealing—some of the solder having been allowed to run into the can.

446. Effects of bad milk.—So called blue milk, or milk covered with a layer of blue fungus, named *Oidium Lactis*, gives rise to indigestion and stomach irritation, apthous affections of the mouth, commonly called thrush, and, according to the observations of Hessling, to even cholera-like attacks. There is good reason for believing that milk contaminated with matter from the inflamed udder of the cow also gives rise to apthous ulceration. Trembles, or milk sickness, is another ailment resulting from milk of diseased cows. Scrofulous diseases, too, may be produced by using the milk of diseased animals (see Sec. 440.) The action of milk in conveying the poison of epidemic diseases has been pointed out in Secs. 313 and 318.

447. Some of the adulterations of milk may be roughly determined by a physical examination and a few simple tests. The lactometer is an

instrument for testing the specific gravity or density of milk. The most common form is that which partially floats in the milk; the less dense the milk, the lower the lactometer will sink. Injustice has sometimes been done by relying upon the lactometer alone; a low specific gravity being sometimes due to a large percentage of cream. On the other hand the rapid rise of cream is not alone a proof that milk is rich. These two factors should be considered together. The richness in fat may be determined by a lactoscope: Vogel's lactoscope consists of a thin glass box (or vessel with glass sides): it is filled with water and held between the eye of the observer and the flame of a candle, and milk is added, drop by drop, till the contour of the flame is lost. The richer the milk the less will be the number of drops required to produce this result. Various substances are added to increase the density when milk has been watered. Starch will yield a blue color with the iodine test; gum will give a blue color with acetic acid and iodine; emulsion of seeds coagulates on boiling; chalk settles to the bottom after standing, and, in common with soda, effervesces on the addition of acid. If an exact determination is required, a quantitative chemical analysis must be made.

448. **Wheat flour** is often rendered unwholesome by the presence of smut, mildew, and other forms of fungoid growth. It is at times adulterated with the flour of other vegetables, and with various mineral ingredients, such as calcium and magnesium sulphates and carbonates. It should be white or only tinged with yellow. It should not feel gritty nor lumpy. Its smell and taste should be neither acid nor mouldy. If a handful is compressed, it should not, on re-opening the hand, fall too readily into powder; this would indicate adulteration or a deficiency of gluten. Small insect forms, such as *acarus* and *weevil*, may be detected by the naked eye or by the microscope; the starch granules of potato and other flours may by the microscope be distinguished from those of wheat. If the starch is washed out of flour and the gluten baked, it should look bright and constitute eight to twelve per cent. of the flour. The practice of removing the outer layer of the wheat, so as to make very white flour, is a bad one; we are thus deprived of a great part of the gluten, the nitrogenous principle of the grain. If any portion is removed, it should be the outer covering of bran only.

449. Bread is very frequently adulterated, either for the purpose of making dark flour look white and fine, or to give increased weight to it, or to stop fermentation in damaged flour. Alum and blue stone are used for purposes of adulteration. The use of these drugs is injurious, both because they tend to conceal the bad character of the flour employed, and also because the bread is thus rendered indigestible. Potato and other flours besides wheat are occasionally used to adulterate bread; of these rice flour is employed to absorb water. Bread is sometimes put into a very hot oven so as to make the crust harden quickly, and thus avoid evaporation of moisture. If bread in which there is a large quantity of water is allowed to stand for a day or two on a flat stone without being disturbed, the lower part of the loaf becomes sodden, while the upper part will be very dry. In important and doubtful cases chemical examination of bread and flour may be made.

450. Butter is frequently adulterated with oleomargarine, butterine, lard and meat fats. The melting point of the latter is from 10° to 40° higher than that of most butters. The microscope and chemical examination will also test adulterations.

451. Cheese is not often adulterated, though it is occasionally with the pulp of potatoes, chestnuts and other amylaceous substances. It is sometimes colored with saffron, Venetian red, carrots and annatto. This last is harmless enough if not mixed with the poisonous chromates. A new compound, lard-cheese, has been recently introduced. Cheese frequently contains the *acarus domesticus*, or mite, and vegetable moulds, but these are not believed to be injurious.

452. Coffee is adulterated with chickory, beans, peas, corn and starch. A kind of clay is also moulded and dried to imitate the coffee bean; the real and imitation beans are then mixed together. Inferior and damaged coffee beans are sometimes treated with injurious chemicals and polished to imitate better grades of coffee.

453. Teas are colored and faced with black lead, Prussian blue, soapstone and chrome yellow. Damaged teas and leaves which have already been used are dried again and put on the market after passing through some of the processes of "facing," as it is termed, by which a "bloom" is imparted to them. Teas are also adulterated with the leaves of other plants. These may be detected by wetting the leaves,

spreading them out and examining their structure either with the naked eye or with the magnifying glass.

454. Cocoa often contains animal fats, flours and oxides of iron.

455. Sugar is adulterated by several additions, such as clay, sand, and bran-dust. The substitution of grape sugar and glucose for cane-sugar and syrup, has become a very common fraud; these substitutes have much less sweetening power, but fortunately they are not injurious to health.

456. Confectionery is adulterated in the same way, and is also rendered injurious by the presence of arsenic, sulphate of copper, prussic acid, tartaric acid, fusel oil and other deleterious substances. The outcry regarding poison in confectionery has been productive of great good: vegetable colors are now much more commonly used. There is still, however, room for extreme vigilance. Lemon and lime-juice are often adulterated with foreign acids. So called fruit-syrups are nearly all artificially prepared from ethers, ethyls, glycerine, etc.

457. Vinegar is frequently adulterated with sulphuric and other mineral acids, the mixture being sometimes colored with burnt sugar.

458. Pickles are colored and rendered injurious by the use of acetate of copper, and by being boiled in brass or copper vessels.

459. Cayenne pepper is adulterated with red lead, Venetian red, vermilion, rice, brick dust, and other substances. Black and white peppers are often mixed with mustard husks, flour, ground linseed, buckwheat flour and other kinds of meal.

460. Mustard is adulterated with wheat-flour and turmeric. A certain amount of flour seems a desirable addition for its preservation, but much more than is necessary is often added. Lead chromate is also sometimes found.

The list of adulterations and of diseased foods might be extended still further, but the above include those of most common interest and importance.

Much good has resulted from the labors of public analysts and health officers. It will have been seen that many of the adulterations are unwholesome, owing to the withdrawal of the proper articles of food. Some few are injurious in themselves.

CHAPTER XIV.

DIGESTION—THE DIGESTIVE ORGANS—THEIR FUNCTIONS—DENTITION—CARE OF THE TEETH—REGULARITY—CHEERFULNESS AT MEALS—USE OF FLUIDS.

461. Digestion is the process by which the nutritious elements are extracted from food. It is a very simple process in the lowest animals, gradually becoming more complex in the ascending scale of organization. In the higher animals the alimentary canal consists of a series of chambers in which the food undergoes successive changes

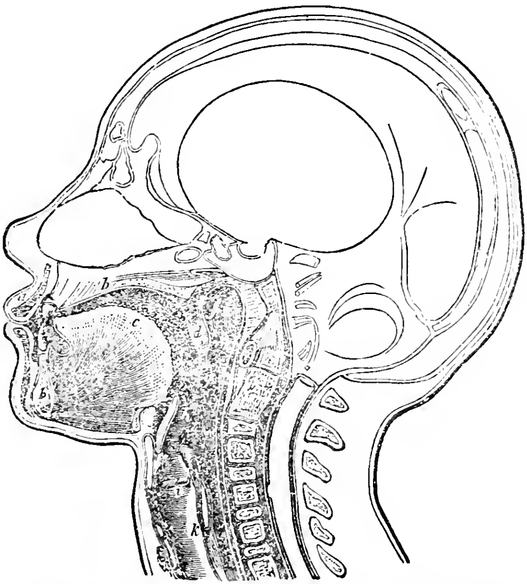


Fig. 51.—*a*, The lips; *b*, the hard palate; *c*, the tongue; *d*, the soft palate; *f*, the upper or post-nasal portion of the pharynx; *g*, the uvula: *h*, the epiglottis; *i*, *k*, the larynx, or upper portion of the windpipe.

antecedently to its separation into nutritive and excrementitious matter, and the gradual assimilation of the food is wrought, not by

the influence of these several chambers and their products alone, but in great part through the chemical agency of copious secretions that are formed in glandular bodies in the neighborhood, and are afterwards conveyed into the different chambers of the digestive apparatus. The regular employment of these important organs, so essential to the continuance of individual existence, has not been left by the Creator to the risk of being neglected, through caprice or accident, but strong desires have been implanted in us, by which we are instinctively prompted.

462. We are led to take food by hunger and thirst. If hunger be not soon appeased, an uneasy sensation of gnawing occurs, which is referred to the pit of the stomach; if thirst be not slaked, the mouth and throat become dry and parched. Sleep allays the sensation of hunger, and violent emotions of the mind prevent it.

463. In the mouth solid food is divided into fragments and rubbed down with a fluid to the consistence of a pulp, that its flavor may produce an impression upon the neighboring sentient surfaces, and that it may in the act of deglutition be readily conveyed in equal portions along the gullet. The inner surface of the mouth is lined with a mucous membrane which is continuous at the lips with the skin. Its vaulted roof (Fig. 51, *b*) is formed by the hard palate, around which are set the teeth in their sockets, the tongue (*c*) forming the floor. The muscular walls of the lips and cheeks retain the food in the mouth during mastication.

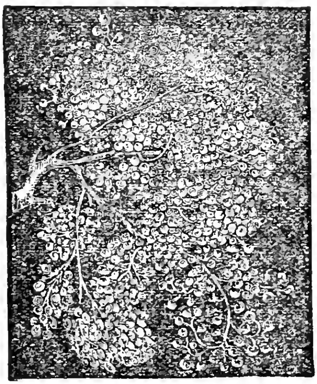


Fig. 52.—A lobule of the parotid gland highly magnified.

464. Saliva is poured into the mouth by three glands on either side—the *parotid* (Fig, 52), the *submaxillary* and the *sublingual*,—and by many smaller glandular bodies in the lips and cheeks, termed the *labial* and *buccal* glands. There is a difference in the structure of these glands, according as they secrete pure saliva, or saliva mixed with mucus, or pure mucus. Mixed saliva is composed (according to Frerichs) of water, ptyalin, proteids, fat, epithelial scales,

sodium chloride, potassium chloride, and other salts. It has the power of converting starch into glucose or grape-sugar. This action is due to the presence of the ferment *ptyalin.*

465. The rate of flow and quantity of saliva are subject to variation. When the tongue and muscles employed in mastication are at rest, and the nerves of the mouth are subject to no unusual stimulus, the quantity is only sufficient for keeping the mouth moist. Mental impressions produced by the sight or thought of food have a tendency to increase it. The quantity secreted is from one to three pints per diem.

466. The teeth in different classes of animals differ considerably, being adapted to the kinds of food best suited to the digestive and other functions of the animal. In some they are evidently intended for seizing and lacerating animal food, in others, on the contrary, they are better fitted for cropping and triturating vegetable foods. It has been shown in Chapter XIII. that a mixed diet of animal and vegetable food is that best suited to the wants of man: and we find that his teeth are so varied in shape as to be well adapted for masticating these different kinds of food: he has chisel-edged *incisors* (Fig. 53, *I*), for detaching the morsel he is about to masticate; pointed *canines* (*O* and *C*) and *bicuspids* (*B*), for lacerating; and broad *molars*(*M*), for triturating.

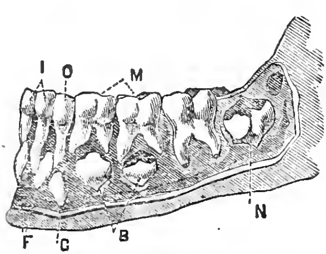


Fig. 53.—The teeth of a child between 5 and 7 years old: *I, O, M,* temporary set, incisors, canines and molars respectively; *F, C, B, N,* incisors, canines, bicuspids and molars of the permanent set, not yet erupted; the tooth shown between *M* and *N* is the first molar of the permanent set, just erupted.

467. The temporary or milk teeth (*I, O, M,* Fig. 53) have only a very short period of existence, which is due to the growth of the permanent teeth, pushing their way up from beneath, absorbing in their progress the whole of the fang of each milk tooth, and leaving at length only the crown as a mere shell, which is shed to make way for the eruption of the permanent tooth.

468. The average times of the eruption of the temporary and permanent teeth are shown in the accompanying tables (Fig. 54). In both cases the eruption of any given tooth of the lower jaw precedes, as a rule, the corresponding tooth of the upper jaw.

469. The teeth may be described as possessing a crown, neck, and fang. The *crown*, or base, covered with enamel; the *neck*, that part of the tooth to which the gum adheres; the *root*, or *fang*, firmly

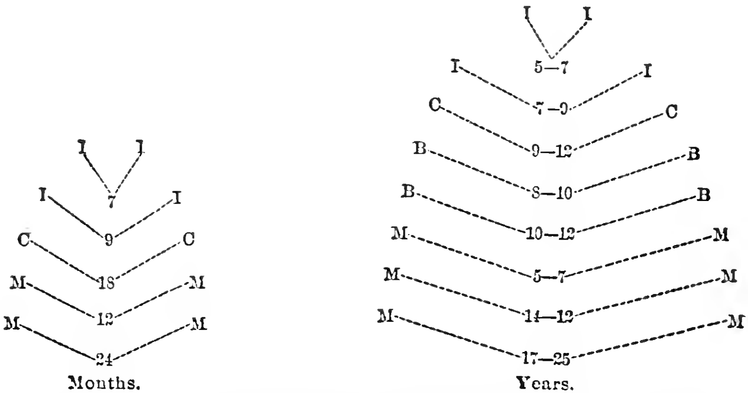


Fig. 54.—Times of eruption of the temporary and permanent sets of teeth respectively: I, incisors; C, canines; B, bicuspids; M, molars.

inserted in the *alveolar process* of the jaw. The tooth is thus fixed by fang and neck, and the crown is employed in masticating the food and in articulating vocal sounds. A longitudinal section of a tooth is shown in Fig. 55. In the centre the *dentine* or ivory (*d*) is hollowed out into a cavity resembling the outline of the tooth, called the *pulp cavity*, from its containing a sensitive and vascular mass called the *tooth pulp*, composed of connective tissue, blood vessels, and nerves. These vessels and nerves enter the pulp through a small opening at the extremity of the fang. The cavity is seen to be wrought in the duller-colored substance or bone of the tooth, and the glistening *enamel* (*a*) appears disposed in a thin layer, thickest upon the cutting edge or grinding surface of the crown, and vanishing upon the neck of the tooth (*b*).

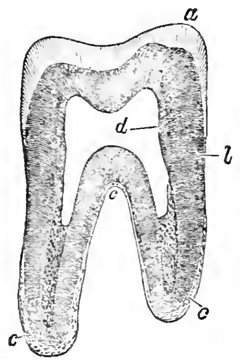


Fig. 55.—Section of a molar tooth: *a*, enamel; *d*, dentine; *c*, cement.

470. The teeth consist of ordinary bone or osseous tissue, and a variety of it called *dentine*, which contains less animal matter, and is

therefore very hard. The *enamel* investing the crown of the tooth, and forming that part which is exposed in the mouth to the contact of external substances, is harder and more compact than dentine and is of peculiar structure, consisting of a congeries of hexagonal rods placed endwise, side by side, their deep surface resting on the dentine. Enamel is the least constant of the dental tissues. The *crusta petrosa* or *cement* (*a*) is disposed as a permanent thin layer of osseous tissue on the roots of the teeth, and it also invests the enamel with a delicate film on the first emergence of the tooth from the gum. The cavity of the teeth, containing the pulp, is the medium for the nutritient vessels and the nerves to find access to the internal surface.

471. The act of chewing or mastication in man is performed by an up and down movement, and a lateral grinding movement of the lower range of teeth against the upper.

472. In deglutition, or the act of swallowing, the morsel of food is thrown by the tongue to the back part of the throat and swallowed, as soon as the saliva has rendered it fit. The upper part of the pharynx (opposite to *g*, Fig. 51), is drawn upwards to receive it. Three muscles, termed the upper, middle, and lower constrictors, then throw their fibres around the pharynx, their action being such as to compress and propel downwards any substance that has found entrance into it. Several passages open towards the pharynx, and there are contrivances which limit the progress of the food to one direction only, and force it to descend towards the œsophagus, instead of allowing it to make its escape by the nostrils, the mouth, or the windpipe. These are remarkable, and well deserve attention.

473. The nostrils are protected by the soft palate (*d*). This is a flap of flexible, elastic substance, about one-fourth of an inch in thickness and an inch in depth, which hangs as a loose curtain above the gullet. The centre of its unattached margin is prolonged to form the uvula (*g*). Laterally two crescentic folds of mucous membrane are reflected from the soft palate to the sides of the tongue and pharynx. Each crescentic fold contains muscular fibres. By these means the communication with the fauces is so straitened that the pressure of the tongue readily precludes the return of the food into the mouth when the muscles of the pharynx contract. But the principal office of the soft palate in deglutition consists in protecting the posterior open-

ings of the nostrils at *f*. For this purpose two additional muscles are supplied, which raise it and press it against the back of the throat, thus cutting off the passage between the pharynx and nostrils.

474. The windpipe is protected by the epiglottis (*h*), a thin leaf of elastic cartilage covered by mucous membrane, rising vertically from the root of the tongue and broad enough when carried backward to cover the aperture of the glottis, or entrance into the windpipe.

475. Deglutition consists then of three stages—the passage of food from the mouth to the pharynx, from the pharynx to the œsophagus, and from the œsophagus to the stomach. The part of digestion which the will controls is limited to the mouth and pharynx—below this muscular action ceases to be voluntary, and common sensation is lost. The elaboration of food now proceeds rapidly; it loses its original qualities and assumes different characters as it is successively submitted, without our consciousness, to the influence of many viscera.

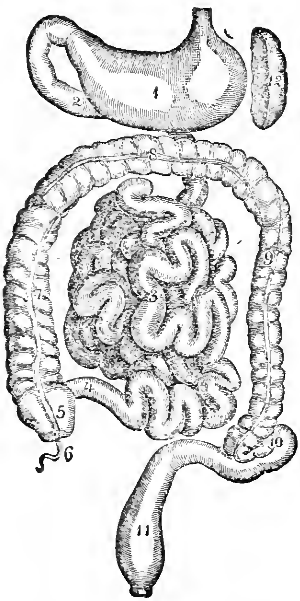


Fig. 56.—The alimentary canal below the œsophagus: 1, stomach; 2, 3, 4, small intestines (duodenum, jejunum and ileum); 5-12, large intestine; 5, cœcum; 6, vermiform appendix.

We may possibly simplify this inquiry into the process of digestion by giving a general account of the nature of the viscera in which the assimilating process is conducted.

476. The alimentary canal, below the pharynx, is a membranous tube of from five to six times the length of the body, the several parts of which are the œsophagus, the stomach (Fig. 56, 1), the small and large intestines (2-4, 5-11). This lengthened tube may be separated into three distinct layers or tunics. The innermost, or mucous coat, so called from the nature of the secretion which exudes upon it, is so delicate as not to allow of being displayed as a separate continuous membrane, until the part has acquired firmness by maceration in alcohol. The surface of the mucous coat is not plain, but somewhat resembles

that of plush or velvet, being covered with a delicate pile, which, where the individual shreds are larger and more distinct, is called a villous structure.

477. The mucous membrane of the stomach is thickly studded with *tubular glands*, of which there are two varieties, *peptic* and *pyloric* or mucous.

478. The gastric juice is secreted in the stomach. It resembles saliva or the ordinary secretions of mucous membrane. Its digestive power depends on a ferment called *pepsin*, and on the muriatic acid which it contains. The office of the gastric juice is to convert the nitrogenous proteid principles of food into *peptones*, thus preparing them to be absorbed into the blood. The food so acted upon is called *chyme*. This stomach digestion is greatly aided by the muscular fibres, which set up a peristaltic movement when food enters the organ; the objects of this movement are to more thoroughly mix the food with the gastric juice, to carry it towards the pyloric orifice as fast as it is formed into chyme, and to propel it into the short portion of bowel continuous with the outlet of the stomach, to which the name of *duodenum* is given. Opening into this is a duct common to the pancreas and liver, and carrying the secretions of these two organs to be mixed with the chyme.

479. The intestinal glands are situated beneath the mucous coat. There are several varieties of them, and their secretions act chiefly as lubricants and diluents.

Near the commencement of each portion of the alimentary canal the glandular apparatus is more extensive and complex: we have seen that the salivary glands are near the fauces; with the stomach and the first four inches of the small intestines are connected the spleen (Fig. 56, 12), the liver and the pancreas; while the cœcum (Fig. 56, 5) or head of the large intestine is more plentifully supplied with submucous glands than any other portion of the large intestines.

480. The Pancreas bears some resemblance to the salivary glands in structure. The pancreatic fluid emulsifies oils and fats, assists in the conversion of starch into glucose, and is supposed to contain a special ferment (*rennet*) by which milk is curdled. It has recently been found to contain also another ferment (*trypsin*) by which any protieds which have escaped the action of the gastric juice are converted into peptones.

481. The liver secretes bile, a fluid supposed to assist in emulsifying the fatty portions of the food, in converting into chyle what is left of the chyme and in preventing putrefactive changes. It also seems to carry off some effete material. The secretion of bile is most active, and the quantity discharged into the duodenum is greatest, during digestion. The quantity per diem is estimated as being from 20 to 40 oz. The liver has also another very important function not thoroughly understood as yet: all the blood from the stomach and intestines passes through the liver before entering the general circulation; it carries with it certain principles of the chyme, namely the peptones and sugars; the liver has the property of converting the sugars into glucose or grape-sugar, and it appears to have some action on the peptones, rendering them fit to enter the blood and subserve the purposes of the economy. It has been observed that the blood of dogs, even when fed solely on meat, contains sugar after passing through the liver

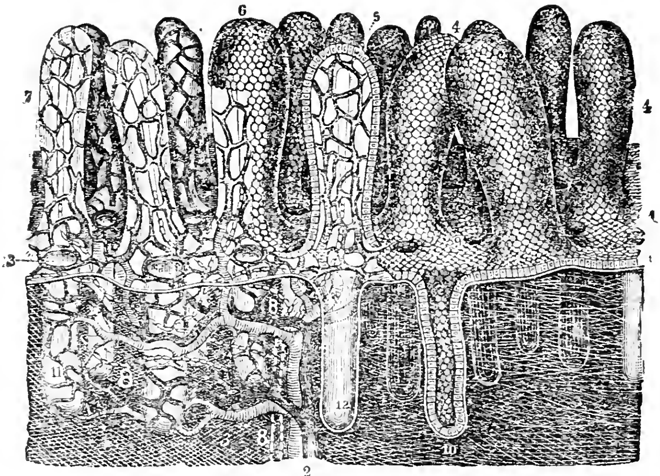


Fig. 57.—The mucous membrane of the small intestine highly magnified: 1, cellular structure of the epithelial surface; 2, artery and vein, the ramifications of which may be seen in the villi; 3, fibrous layer; 4, villi covered with epithelium; 5, a villus in section, showing its covering of epithelium, with its blood-vessels and lymphatics; 6, a villus partially uncovered; 8, 8, 8, lymphatics or lacteals; 10, 11, 12, glands; 13, capillaries surrounding the orifices of the gland.

Whether the formation of sugar takes place under normal circumstances during life has been questioned by some, and the purposes of this supposed sugar-making function have not yet been made clear.

482. The absorption of the products of digestion takes place by means of the blood-vessels and of certain vessels called lacteals. The peptonoid and saccharine portions, along with water, salts, and other inorganic principles, are absorbed principally by the blood-vessels. A certain amount of this absorption takes place in the stomach, but a much larger amount in the intestines. The absorbing surface is greatly increased by the *villi* of the intestines (Fig. 57). These are elongated cones arising from the inner surface of the intestines. Each villus is covered with epithelial cells (4), and contains a network of blood vessels (7) and a *lacteal* (8). The little veins of the villi carry the food-laden blood by means of larger veins (2) to the *portal vein* whence it passes to the liver (Sec. 480) and being again collected by the *hepatic vein* (*h. v.* Fig. 1) it empties into the *inferior vena cava* and so passes to the right side of the heart. The fatty emulsion, or chyle proper, is absorbed by and passes through the *lacteals* and *lymphatics*, and is by them carried to the *thoracic duct*, a long tube which in man empties its contents into one of the *subclavian* veins, and so the chyle mingles with the blood, and is carried to the heart by the *superior vena cava* (*s. v.* Fig. 1).

483. Care of the teeth.—It is commonly supposed that, because the first set of teeth in children are only temporary, they do not require attention. This is a great mistake, for the regularity of the permanent teeth depends very much upon the retention of the first set until the second is ready to appear. Besides, the general health of the child will be promoted by keeping the teeth in good condition, that mastication may be performed without pain; otherwise the child will soon learn to avoid that which is painful, and to swallow its food without proper mastication; the commencement of indigestion will thus be established. The mother should, therefore, make it part of her daily care to secure the habitual cleanliness of the teeth. Early accustomed to it, the child, when old enough to use a soft tooth-brush, will not feel comfortable until the teeth have been carefully cleansed. If decay commences, the same care should be taken to prevent its extension as in the permanent teeth, for premature loss will cause irregularity and disfigurement of the latter set. By proper attention to the cleanliness of the teeth not only is the formation of tartar prevented, but the removal of particles of food and other extraneous matters is

secured. The influence of this tartar is in some cases exceedingly pernicious, causing the gums to become swollen and spongy, to suppurate about their margins, and to recede from the necks of the teeth. The gums become so painful that a tooth-brush cannot be used. The tartar accumulates rapidly, and as a result, destruction of the alveolar processes occurs; the teeth become loose and drop out. Derangements of the digestive functions and impairment of the whole economy may result. One of the chief causes of caries or decay of the teeth is the fermentation and decomposition of food about and between them. Gritty tooth powders should be carefully avoided.

484. The importance of regularity in taking nourishment is admitted by all writers. The requirements of the human system seem to be best met by having three meals daily—morning, mid-day and evening. —and there should be no eating between meals. The processes of digestion, which have been described, require a sufficient length of time for their performance, and we must not add fresh material to a half completed process. The evening meal should precede the usual time for going to bed by at least three or four hours. Persons who from any cause have feelings of exhaustion between meals may take a glass of milk with advantage. Some persons cannot sleep if some hours have elapsed since they have partaken of food. To such persons a little bread and milk, or other easily digested food, will be beneficial. We must not, on the one hand, allow so long a period to elapse without food that the tissues become exhausted, and the craving for food becomes painful or unpleasant; nor, on the other hand, commence a second process of fermentation before the digestive chambers have finished the elaboration of a previous supply of food.

485. Insufficient time for partaking of a meal is a very common error. Food requires to be well masticated in order that it may be in a finely divided state when mixed with the digestive fluids, and also that it may be mixed with a sufficient quantity of saliva: the act of chewing causes an increase in the flow of the latter.

486. We should not take fluids to moisten a bolus in the mouth. This, too, will diminish the amount of saliva: there will not be the same demand for it if we have an extraneous fluid to perform one of its mechanical offices. In this way salivary digestion will be impaired; the gastric fluid also becomes diluted and weakened.

487. Cheerful conversation during and after meal times is a good aid to digestion. Hard work, either physical or mental, should be avoided at meal times and for a short time afterwards. The blood is required in increased quantity in the digestive organs, and must not be diverted to the brain and muscles. The nervous system has a powerful modifying and controlling influence on digestion, hence any strain upon that system will interfere with the digestive process; violent mental emotions have this effect.

488. The free use of ice cold drinks while taking food may depress the nerves of the digestive organs and thus diminish the blood supply required for the functional activity of the stomach. In this way the digestive process may be arrested and dyspepsia induced. When a person is overheated the use of large draughts of very cold fluids may cause too great and rapid cooling. Otherwise cold drinks are refreshing and beneficial in warm weather.

CHAPTER XV.

ALCOHOL: IS IT A FOOD?—DOES IT PRODUCE HEAT?—ITS PHYSIOLOGICAL ACTION—DESTRUCTIVE CHANGES IN THE VITAL ORGANS AND BLOOD—MORTALITY AND DISEASE STATISTICS—DANGERS OF TREATING AND MODERATE DRINKING—TEACHERS SHOULD BE ABSTAINERS.

489. **We find that nature produces all the necessary elements** required for supporting human life. In her laboratory organic elements and compounds are continually being gathered and prepared for the use of man in sustaining the powers and activities both of mind and body. This has been fully shown in the chapters on Food and Water.

490. **Whether alcohol is necessary or useful as a food** under any circumstances is a question we may be asked to consider. The fact that it is not found among the varied compounds existing in animal and vegetable substances in their natural condition, is, of itself, sufficient to exclude it from the list of necessary articles of food.

491. **Alcohol in fermented drinks** is combined with nutrient substances, and in this form it is more likely to be assimilated. It is held by some authorities that in small quantities, about an ounce in twenty-four hours, it may be oxidized and assimilated in the system, yielding force to the bodily organism, and that in persons unaccustomed to its use, it may increase the flow of gastric fluid and other gland secretions. After a time, however, the habitual moderate drinker finds it necessary to increase the dose in order to obtain the same effects as were produced by the original smaller quantity. When this period arrives organic disease has resulted, as hereafter described in this chapter.

492. **That the habitual beer-drinker is usually short-lived,** and that diseases of the liver heart and kidneys, are commonly the result of excessive beer-drinking is affirmed by medical practitioners, and admitted by those who have had opportunities to form a correct opinion.

493. At a meeting of the International Medical Congress, held in Philadelphia in 1876, and attended by delegates from all parts of the civilized world, the following resolution was adopted:—"Alcohol is not shown to have a definite food value by any of the methods of chemical analysis or physiological investigation."

494. Is it serviceable as a heat producer? It has been frequently asserted that alcohol belongs to the heat-producing foods, and that it is capable of maintaining the natural animal heat of the body. So far as its chemical composition is concerned, it contains the elements required for combustion and the production of heat, and, in this respect, is of great use to the chemist. But as commonly used in the form of spirits, such as whiskey, brandy, etc., its chemical heat-producing properties are much less than those of starch or sugar, and very much less than those of fats. Alcohol, as used in our ordinary drinks, contains carbon, 2 parts, hydrogen, 6 parts, and oxygen, 1 part. Bartholow, in his *Materia Medica*, classifies alcohol, ether and chloroform as "cerebral sedatives," that is, "remedies which diminish or suspend the functions of the cerebrum after a preliminary stage of excitement." It has been asserted by writers on the physiological effects of alcohol that during this "preliminary stage of excitement" the temperature of the body is raised. Dr. B. W. Richardson, in describing these effects, groups them into four stages:—

495. In the first stage, he says, "The involuntary muscles which regulate the flow of blood through the minute circulation are weakened. The flood-gates of the circulation being opened, all the organs of the body are flushed with blood, the temperature of the body is raised, the heart is quickened in action, the breathing is quickened, and the mind is excited." He attributes the reddening and warming of the surface of the body which characterize the first exciting effects of alcohol, to the pouring of an increased and imperfectly regulated volume of blood into the fine vessels of the surface.

496. "This seeming warming is really a process of cooling." So much blood brought to the surface, unless the air is very warm indeed, is robbed of warmth by exposure, and returns to the heart by the veins chilled. Let us call to mind the physiology of the circulation. In all arteries the middle coat contains plain muscular fibres arranged circularly. As they become smaller, the muscular element

becomes more prominent, as compared with the elastic element. As the blood proceeds on its course from the impulse of the heart, it becomes more and more subject to the control of these remote, or distal arteries, as they are called. Nature has provided them with power for directing and regulating the flow of blood in accordance with the requirements of the body. There are nerve fibres whose special function it is to impart power to these minute arteries, enabling them, by virtue of their muscular coats, to contract and dilate, so as to regulate the distribution of blood. This system of nervous control has received the name of "the vaso-motor mechanism." The fine capillary vessels in the skin, lungs, etc., at the very extremity of the arteries have no muscular element. By virtue of their elasticity, they are expanded when a large supply of blood is sent to them, and again constricted when the supply is lessened. In both cases their share is a passive one. When the body is healthy and vigorous, this power to direct the flow of blood is in full strength. It is called "arterial tone," and is a powerful element in determining the flow of blood to the various parts and organs of the body.

497. The action of alcohol in paralyzing this vascular tone is aptly described by Dr. Richardson as an opening of the flood-gates of the circulation, by which the organs of the body are flushed with blood. Hugh Owen Thomas, M.R.C.S., of Liverpool, in an article on "The Action of Sedatives and Stimulants," states that opium and alcohol belong to the class of pure sedatives. He says their effects may be best observed by noticing their physiological influence on the iris, heart, blood-vessels and viscera. The iris is made up of radiating and circular muscular fibres

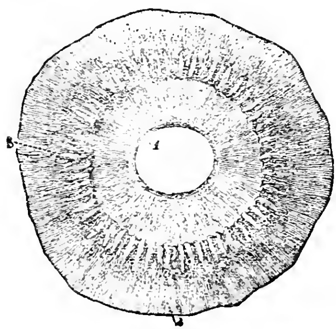


Fig. 58. – The iris and ciliary processes, as seen from behind.

(Fig. 58): contraction of the radiating fibres causes the pupil of the eye to become large, contraction of the circular fibres decreases its size. If a full dose of opium is given, the diameter of the pupil is diminished. This is caused by the drug having a primary sedative or paralyzing action upon the radiating muscular fibres, through its

primary affinity for the sympathetic system of nerves which especially controls these fibres. A larger and dangerous dose causes paralysis of the circular muscular fibres also, through its further action on the cerebro-spinal system of nerves, and hence the pupil becomes largely dilated.

498. The effect of opium upon the circulation is to act first on the blood-vessels, and, secondarily, on the heart: to cause an increased volume in the pulse from diminished arterial tonicity, and then a lower rate of beat, when the dose has been sufficient and has had time to influence the heart. Mr. Thomas claims that the action of alcohol is precisely similar to that of opium: it primarily affects the sympathetic system, secondarily the cerebro-spinal system of nerves; it has the same action on the iris, contracting and dilating the pupil in the same way; it first attacks the blood-vessels through the sympathetic nerves, diminishing their tonicity; this relieves the heart of blood-pressure, and causes a temporary acceleration of the pulse and general circulation.

499. All these indications point to a paralyzing or sedative action, to diminution of control over the circulatory system and not to real stimulation. The signs of apparent stimulation by alcohol arise from the primary affinity that certain doses of alcohol have for certain nerve structures.

500. Experiments on animals have been made with a view to discover the principles of action of the vaso-motor mechanism—the nerve-control of the blood-vessels. As a result of some of these experiments, it is recorded* that in mammalia, the division of the sympathetic nerve in the neck on one side causes a dilatation of the minute arteries of the head on the same side, and an increased flow of blood to these parts. If the experiment is performed on a rabbit, the ear of the side operated on is much redder than normal, its arteries are obviously dilated, its veins unusually full; innumerable minute vessels, before invisible, come into view, and the temperature may be more than a degree higher than on the other side. Division of the sciatic nerve (the large nerve of the leg) causes a similar dilatation of the small arteries of the leg and foot. The vessels of the toes appear full of blood, and a thermometer placed between

* Text-book of Physiology, by M. Foster, M.A. M.D., F.R.S., Lea's edition, 1881, p. 254.

the toes indicates a rise of temperature amounting to several degrees. Numerous other experiments have been performed, showing precisely similar effects in other parts of the body.

M. Strauss, in the *American Journal of the Medical Sciences*, is reported as relating the case of a soldier who suffered from a disease of the vaso-motor nerves of the left foot. The foot and toes were swollen owing to the engorgement of the vessels, especially when the patient was sitting and the leg hanging down. In this case the temperature of both sides was reported daily. It was found that there was a difference between the two, that of the left being from two to four degrees higher than the right. From these, and many similar facts, it appears that increase of temperature on the surface of the body, or in any part, may arise from abstraction of heat from another part. It seems very probable that the rise in temperature observed during the first action of alcohol on the system is only the result of its sedative or paralyzing influence on the minute arteries controlling the blood supply.

501. Alcohol does not maintain animal heat, but, on the contrary, permits an excessive expenditure of it. It is admitted by all observers that the secondary effect of alcohol is to lower the temperature of the body. Even those who advocate its use as a stimulant, and who affirm that it may, under some circumstances, be of value as a food, are ready to admit its secondary effect in reducing animal heat.

502. Arctic voyagers have given us their experience regarding the use of spirits in enabling men to endure long-continued cold. Dr. Rae, Dr. Kane, Dr. Hayes, and all those who have been engaged on expeditions in Polar regions, are agreed in the view that the use of alcohol in moderate quantities diminishes the power to resist cold. Experiences in the Red River Expedition, in the Ashantee war, in India, and in other regions, show that the ability to endure fatigue and to resist disease is lessened by the habitual use of alcoholic stimulants. Such evidence as this coincides with the results of observations regarding the physiological effects of alcohol on the blood, and in the circulatory and nervous systems of man. We may conclude that alcohol does not supply the place of foods in maintaining the vigor or animal heat of the body.

503. When alcohol comes in contact with living tissues it hardens

them. This physiological effect is said to be due to the abstraction of water and the coagulation or condensation of albumen.

504. In the mouth alcohol causes an increased flow of saliva, and a hardening of the epithelium, or lining membrane, which is recognized by a feeling of contraction or "puckering of the mouth." In this way the natural condition of the tissues is impaired.

505. Repeated and long-continued use of alcoholic stimulants finally brings about an unnatural condition and impaired function, which may be seen in the glazed and fissured tongue of the habitual drinker of ardent spirits.

506. Congestion of the mucous membrane, or lining membrane of the stomach, results from the habitual use of alcohol. The minute arteries in this membrane become dilated, and allow an increased amount of blood to pass through them; the natural secretion of the stomach, the gastric fluid, is temporarily increased by this excessive flow of blood. The long-continued and habitual use of alcohol thus brings on a chronic congestion, or gastric catarrh. The excessive natural secretion now begins to change to an unnatural one, the digestive functions being at the same time impaired. The glands, or mucous follicles, begin to show evidence of organic change. The continued excessive flow of blood induced by constant alcoholic stimulation causes an increased growth of the connective tissue. This encroaches upon the glands and mucous follicles, which are constantly being drained by an unnatural excessive secretion, and thus they are reduced in size, and fail to maintain their healthy form and function. Alcohol is also said to precipitate pepsin of the gastric fluid and arrest the activity of the ferment.

507. The information derived by Dr. Beaumont in the case of Alexis St. Martin is valuable in this connection. This man was accidentally wounded in such a way that through the imperfectly healed wound the operations of the stomach could be watched. He had been habitually a temperate and healthy man. "After drinking ardent spirits for eight or ten days, he complained of no pain, and showed no signs of indisposition—said he felt well, and had a good appetite. The inner membrane of the stomach, however, was in an unnatural condition, having an erythematous or rose-colored appearance, and apthous or inflamed spots. The secretion also was unnatural."

Under the continued use of spirits this unnatural condition increased, and it is reported that, "The gastric fluids extracted from the stomach this morning were mixed with a large portion of thick, ropy mucus, and considerable muco-purulent matter, slightly tinged with blood, resembling the discharge from the bowels in cases of chronic dysentery." During all this deranged condition, Dr. Beaumont remarks that, "St. Martin complained of no symptoms indicating any general derangement of the system, except an uneasy sensation and a tenderness at the pit of the stomach, some dizziness, with dimness of vision on stooping and rising again." These observations prove that well-marked pathological changes and serious derangement of the functions of digestion may occur without any outward symptoms in the case of those who habitually use spirits even in small quantities.

508. The liver is the organ most influenced next after the stomach. Alcohol is absorbed into the blood-vessels of the stomach and intestines, from these it passes directly through the portal vein to the liver cells. Changes are here observed similar to those in the stomach: first, increased functional activity; next, impairment of function; then the organic structure of the liver suffers, fatty deposits occur and take the place of the natural tissue, the liver is improperly nourished, and its firmness of texture is lost; the connective tissue increases partly at the expense of the hepatic cells, and the liver becomes enlarged; after this, contraction of the superabundant and newly-formed connective tissue takes place. This reduction in size brings about that condition of the liver known as cirrhosis. This disease, common in the case of habitual drinkers, causes a miserable existence, closed by death.

509. The kidneys also are injuriously affected by the habitual use of alcohol. It reaches them by the general circulation, and, therefore, does not so quickly or intensely excite inflammatory action in them as in the liver. The long-continued use of spirits, however, causes chronic disease of the kidneys: as the result of constant irritation, the functions of these organs are impaired, and finally alterations of structure are effected, frequently causing the disease known as granular degeneration of the kidneys, or Bright's disease. Deposits of matters incapable of organization are found in the substance of the

kidneys. We have, first, excessive growth of the intertubal or connective tissue, and then a shrivelling or contraction of the tissue or substance of the kidney, to the extent, in some instances, of one-half its natural size. Various other organic changes afterwards occur. There is a similarity to be observed in the alterations of the organic structure of the kidneys and liver, as a result of continued alcoholic stimulation. In both cases, also, the diseases are incurable after the organic changes have been accomplished.

The liver and kidneys (especially the latter), are engaged in the function of excretion, or carrying off morbid matters that should be ejected from the system. The altered conditions just described lead to impairment of this function. Poisonous materials are thus retained in the blood, and diseases of various kinds produced. Gout, rheumatism, affections of the heart and other organs, have been known to arise under these circumstances from very slight exciting causes. The natural tendency to repair injuries, resist disease, and alter morbid conditions, is greatly lessened.

510. The direct action of alcohol on the blood is such as to impair its nutritive, formative and reconstructive powers. The vital properties of the corpuscles are partially destroyed and their functions impaired. This was well illustrated by Dr. George B. Harriman, of Boston, in connection with a lecture by the Rev. Joseph Cook. He exhibited, with the aid of a microscope and magic-lantern, the magnified corpuscles of healthy blood, and also of the blood of inebriates. In the presentation of healthy blood, the corpuscles stood out upon the screen clear, round and well defined. Those of the inebriate were shrunken, distorted, irregular in outline, sometimes without coloring matter, and with here and there growing from them a fungoid filament. It was stated that "alcohol drives out the coloring matter, which settles in fine pigment granules in other morphological elements of the blood, and in the edges of the white corpuscles," and that spores and dark granular pigments were numerous in the fluid of the blood. The natural power of the blood to form fibrine is lessened. This accounts for the fact which has been frequently noticed, viz., that the healing process is very slow and feeble in drunkards; the power to resist contagion is also lessened, and the ability to recover from fevers, erysipelas and other diseases is very much less. It is a

common observation, that the slightest scratch in the case of an habitual drinker may cause an unhealthy sore or erysipelas.

511. The skin suffers from perverted action and disordered nutrition, as shown by frequent eruptions on the face and surface of the body.

512. The removal of superfluous fatty matter is prevented by the habitual use of alcohol. Healthy natural deposits of fat beneath the skin, and in some other parts of the body, are necessary, but an undue accumulation and retention of fatty matter leads to fatty degeneration of muscular tissue and of various organs. Thus, excessive fatty deposit may become a positive disease, and cause organic changes which destroy life. In this way, frequently, the natural hardness and vigor of muscles is destroyed, their contractile power is lessened, and they are said to suffer from want of tonicity. The muscular structure of the walls of the heart and of the arteries is injuriously affected : they lose their contractile power and natural firmness, and serious derangement of the general circulation results. Arteries in this condition frequently give way from the internal pressure of the blood current, and fatal effusions of accumulated blood take place. Apoplexy, paralysis and epilepsy are sometimes caused by ruptures of the walls of blood-vessels in the brain. Alcohol circulating in the current of arterial blood may cause inflammation of the internal coats of arteries. In this case coagulation of blood is apt to occur as a result of the inflammatory changes, and mechanical obstruction of a large artery may be produced by a blood clot thus formed : atrophy, or even death, may result in the part so deprived of its natural support and nutrition. Deposits have been known to occur in the walls of the heart also, as an effect of the irritation of alcohol.

513. Alcohol acts directly on the brain, the great nervous centre of the body. Hammond has proved that it has a special affinity for nerve tissue and nerve centres. It has been found in the brain substance, and in the fluid of the ventricles of the brain. That terrible disease, delirium tremens, is caused by excessive drinking. Many chronic and incurable diseases of the brain and nervous system have resulted from the habitual or excessive use of alcoholic stimulants. Among such diseases, paralysis, loss of sight and epileptic fits are

most common. They are seen in various stages and degrees of intensity. The statistics of asylums prove that insanity is often the result of continued drinking. It is sometimes the cause of indulgence in the use of intoxicating liquors.

514. Death may result from an overdose of alcohol. In proportion as intoxication increases, the will power, or controlling power of the cerebro-spinal system, becomes lessened. First the intellectual and moral faculties are blunted, then the part of the brain controlling the muscles and muscular movements of the body is affected, and the respiratory power finally comes under the influence of the poison, heavy or stertorous breathing occurs, insensibility or stupor comes on, and the functions of organic life may cease.

515. Statistics show that life is shortened by intemperate habits. It has been found by Mr. Neison, an eminent actuary, quoted by the late Dr. Parkes and others, that the rate of mortality at the age of 21–30 is five times greater among the intemperate than among the temperate; at the age of 30–40 it is four times greater; the disproportion gradually becomes less after that age. The probability or "expectation" of life he gives as follows:—

At the age	In the temperate.	In the intemperate.
Of 20	44.2 years.	15.6 years.
" 30	36.5 "	13.8 "
" 40	28.8 "	11.6 "
" 50	21.25 "	10.8 "
" 60	14.28 "	8.9 "

As a result of such calculations, no reliable life insurance company will issue a life policy in favor of one whose habits are intemperate, and a false statement in this particular may render the policy, if issued, null and void.

The late Dr. Hitchcock, President of the Michigan State Board of Health, sent out to some two hundred physicians in Michigan, and to the same number in other States, a circular asking for certain information. One of the questions asked was, "What percentage of deaths in adults within your observation during the last year is due directly to alcohol?" The replies placed the percentage variously from one to fifty, the average being thirteen and a half. In a paper read before the Philosophical Society of Glasgow, Mr. K. McLeod pointed out

that the death-rates of the various districts in that city were in direct proportion to the numbers of public-houses. The experience of the United Kingdom Temperance and General Provident Institution has proved that even among persons who have passed the examination for life insurance, there is a much larger rate of mortality amongst those "not known to be intemperate" (moderate drinkers) than amongst total abstainers.

The government returns obtained in 1849, and published by Dr. W. B. Carpenter, give the rate of mortality among the European troops in Madras. These troops were divided for purpose of comparison into three classes—the total abstainers, the temperate, and the intemperate. The return of deaths is as follows:

1.	In Abstainers	11 in 1000
2.	In Temperate	23 in 1000
3.	In Intemperate	44 in 1000

516. The disease statistics amongst these same classes, as indicated by admissions to hospital, were in the proportions of 1,308, 1,415 and 2,148 respectively. Dr. S. G. Howe, of Massachusetts, states that of 300 idiots regarding whom he made inquiries, 145 were children of drunken parents. In addresses by the late Dr. Hitchcock and Dr. W. B. Carpenter, the statements of many authorities, both European and American, are given, all showing that a large amount of disease is caused by the use of alcohol. Mr. Macleod, Professor of Surgery in Glasgow University, is quoted as saying, "that ninety-nine out of every hundred cases in the accident wards of our infirmary are the result of drink." Granted that this is an exaggerated estimate, it shows at least that the proportion must be very large.

517. Teachers should abstain from all intoxicating drinks. Their own interests require it. In order to cultivate that physical and mental vigor required of them, it is very necessary that no habits should be indulged in which may in the slightest degree impair their health. Their success in accomplishing all that education in the highest sense demands, depends on the example and influence exerted by them in the school-room. Therefore all evil habits that tend to impair natural powers of action or thought should be carefully avoided.

518. To set an example of abstinence from the use of all intoxicating liquors is the only way to avoid the responsibility of leading

others into habits of intemperance. Precept cannot exert an influence where practice is at variance with it.

519. **Tobacco is injurious** when used by young persons whose physical development is not completed. In persons unaccustomed to its use, increased flow of saliva, nausea and muscular weakness are produced. When larger quantities are used, vertigo, general weakness, universal relaxation, depression and increased frequency of the pulse, coolness of the surface, faintness and vomiting ensue.

520. **Persons who habitually** use tobacco in moderate quantities for a length of time experience its effects as a nervous sedative. In some an agreeable, tranquilizing effect is produced, quieting restlessness. In persons of nervous temperament it cannot be used even in small quantities without disadvantage, while in others no evil effects follow.

521. **The habit should not be indulged in, however,** as it yields no good results, and is an uncleanly, useless and expensive practice. Among the more permanent effects resulting from the long-continued use of tobacco, may be mentioned dyspepsia, defective nutrition, emaciation, general debility, palpitation of the heart and hypochondriasis.

522. **Acute poisoning may result** from the use of a large quantity, and sometimes death occurs. Dangerous and even fatal effects have resulted from the external application of fresh tobacco juice to the scalp in cases of ring-worm.

523. **Opium, chloral,** and other narcotics are often indulged in for the sake of their soothing or tranquilizing effects on the system. Frequently the practice has grown from their employment during attacks of neuralgia and other nervous affections. In their use there is danger of forming an uncontrollable habit, with disastrous results.

524. **Narcotics** should never be taken except when prescribed by a physician. The indiscriminate and dangerous manner in which opium in the form of soothing syrups is given to infants by their mothers and nurses, cannot be too strongly condemned. In addition to the more slowly injurious effect, acute poisoning frequently occurs from the use of these preparations, the strength of which is very variable.

CHAPTER XVI.

WATER: ITS USES—QUANTITY REQUIRED—SOURCES OF SUPPLY—THEIR NATURE—COLLECTION—STORAGE AND DISTRIBUTION—IMPURITIES—THEIR DETECTION—THEIR EFFECTS—PURIFICATION OF WATER—DRINKING-WATER FOR SCHOOLS.

525. A sufficient supply of pure water is necessary for sustaining human life. The uses of water in connection with nutritive changes, and the assimilation of food, have been already considered. The various beverages used by man are mostly water, holding in solution substances of various kinds. Many of these are beneficial if used properly. It is possible, however, to use fluids in such large quantities that the digestive process is interfered with.

526. The function of excretion is promoted by the drinking of water. Urea, a waste product remaining from the transformations of nitrogenous foods, is naturally thrown out by the kidneys. The retention of this in the blood in undue quantities is very injurious and often fatal to life. A suitable supply of pure water is necessary to maintain the functional activities of the kidneys, and enable them to get rid of poisonous elements. Water-drinking also favors cutaneous perspiration, especially when encouraged by external warmth; it thus assists the skin to carry on its function of excreting waste materials. The total amount of perspiration is greatly influenced by the amount of fluid drunk, as well as by the condition of the atmosphere and the nature of the food taken. In certain diseases of the kidneys it has been found necessary to reduce the quantity of urea-producing food and increase the amount of water taken by the patient, in order to promote a more healthy action of the excretory organs.

527. A supply of water for bathing is not only a luxury but is necessary for health. The chapter on Bathing refers to this more particularly. Skin diseases and various other affections, such as

typhus fever, scarlatina, and other malignant fevers, diphtheria, and opthalmia, have been known to arise from a deficient supply.

528. The quantity of water per head per diem required in a mixed community was measured and calculated by the late Dr. Parkes, as follows :—

For cooking	0.75	gallons.
Fluids in drink (water, tea, coffee)	0.33	"
Ablution, including a daily sponge bath, which took from 2½ to 3 gallons	5.00	"
Share of utensil and house washing	3.00	"
Share of clothes (laundry) washing	3.00	"
In round numbers	12.00	"
If general baths and water-closets are used, we must add to this an additional	13.00	"
Making for house use a total of	25.00	"

For sick persons this is to be raised to an amount varying from 38 to 46 gallons. The above amounts are those required for domestic use only, irrespective of watering streets, extinguishing fires, and the various requirements of trades and manufactures, for which 5 to 10 gallons more must be added. Other experiments have sustained these figures. In communities where people have had much trouble in carrying water, smaller amounts have been used; but in some of these instances a want of cleanliness and health has been the result. For obtaining the best sanitary conditions it is necessary that the above amounts should be available.

529. All supplies of fresh water come from the aqueous vapor of the atmosphere. By condensation this falls to the earth as rain or snow; a portion sinks through the various strata of the earth, and re-appears in springs or wells; a portion also flows directly into streams and lakes on the surface, where, by exposure to the sun's rays, it may again be returned in part to the atmosphere as aqueous vapor. The nature of the soils and of the geological strata through which water passes, governs to a great extent its character.

530. Rain water, as it falls, becomes mixed with certain substances contained in the atmosphere, such as carbon dioxide, ammoniacal salts, nitrates, nitrites and oxygen. In thickly populated districts it carries down with it vast quantities of dust, smoke-particles, pro-

ducts of animal and vegetable decay, and acids or other matter commonly floating in the air of manufacturing districts. It is also liable to contamination from the roofs of houses from which it is collected. Contrivances have been devised for getting rid of the first washings from the roofs, but they are little used. Rain water is devoid of lime or calcium carbonate, which is usually found in spring water, and in a less degree in river or lake water. This constituent renders drinking water more sparkling and palatable; it also furnishes an element, lime, necessary for the building up of bone.

531. **Pure spring water** is the most wholesome for drinking purposes. The soil, however, is much richer in carbon dioxide than the air, and contains mineral substances, such as calcium, silica, sodium, etc Rain water, receiving more or less carbon dioxide from the air, absorbs an additional quantity in the soil, and becomes charged with calcium carbonate, sodium silicate, salts of ammonia, and other compounds, the elements of which may happen to be present in the various soils.

532. **Rivers, streams, lakes and ponds** vary much as to purity. Where they are passing through, or contiguous to, thickly inhabited districts, organic impurities from dwellings, from manufactories, and from all kinds of refuse, are found in abundance, and if the bodies of water are small, the impurities will be the more concentrated. The constant movement of water in swift-running streams, or by the agitation of waves, tends to oxidation of these organic impurities. Rivulets and spring brooks passing through rural sections of country are usually pure and very wholesome. Instances are frequently met with, however, which should lead us to increased watchfulness, lest they may be contaminated in some unsuspected way. Sea-water is sometimes distilled to obtain water for drinking and other domestic purposes.

533. **Water in wells** is more likely to be contaminated than water from other sources. Contamination of shallow wells is a very common source of disease. Surface water, becoming polluted with the refuse from dwellings in thickly inhabited places, and percolating through loose alluvial soil into wells, is certain to be unfit for drinking purposes. Where the soil is rich in organic matter, the water may contain 10 to 30 grains per gallon of organic impurities. In

marshy districts there may be 10 to 100 grains of vegetable matter. Waters containing a large percentage of such impurities have a yellowish or brownish tint. Occasionally, by constant percolation of surface water through a loose soil, a channel may be formed through which a sudden discharge of impure water may pollute the well. Wells that are not constantly used and very deep wells are liable to become impure from imperfect aeration; frequent pumping out of the water is necessary to maintain a state of purity. Surface water from higher ground, even at a considerable distance, may drain into wells. In order to prevent this a wall of good masonry should project above the surface of the ground from the wall surrounding the well. For a proper distance down in the well this wall should be constructed so as to prevent leakage of surface water into the well. It may be surrounded with puddling clay, well packed, till an impervious soil is reached. Roots of trees sometimes find their way into wells, and there decay and produce injurious results.

534. Tubular wells have sometimes to be resorted to. They have been largely used by the British army in foreign service. A perforated iron tube with a sharp hard point is driven into the ground, other lengths of tube are then attached and driven down, and the process is repeated till water is reached. Driven wells in contaminated districts should be protected in the same way as others.

535. Sewage contamination of water. The waste and surface waters from dwellings, stables and barn-yards, containing solid and liquid manure, excreta, and numerous animal and vegetable substances, are the most frequent sources of contamination of drinking water. Wells or cisterns near dwellings are often found to contain water impure from this cause. Fig. 59 is a graphic illustration of this source of danger. In some sections of the country great carelessness has been displayed with regard to the position and management of wells. The owners of houses in the country cannot plead the same scarcity of space as those in the city, and yet their wells are often contaminated by too close proximity to the sources of impurity just alluded to. There is not sufficient care taken, either, to prevent domestic animals from polluting the wells, the ground around these being often a favorite resort and resting place for cattle and poultry.

536. Provision for the storage of water has to be made in those

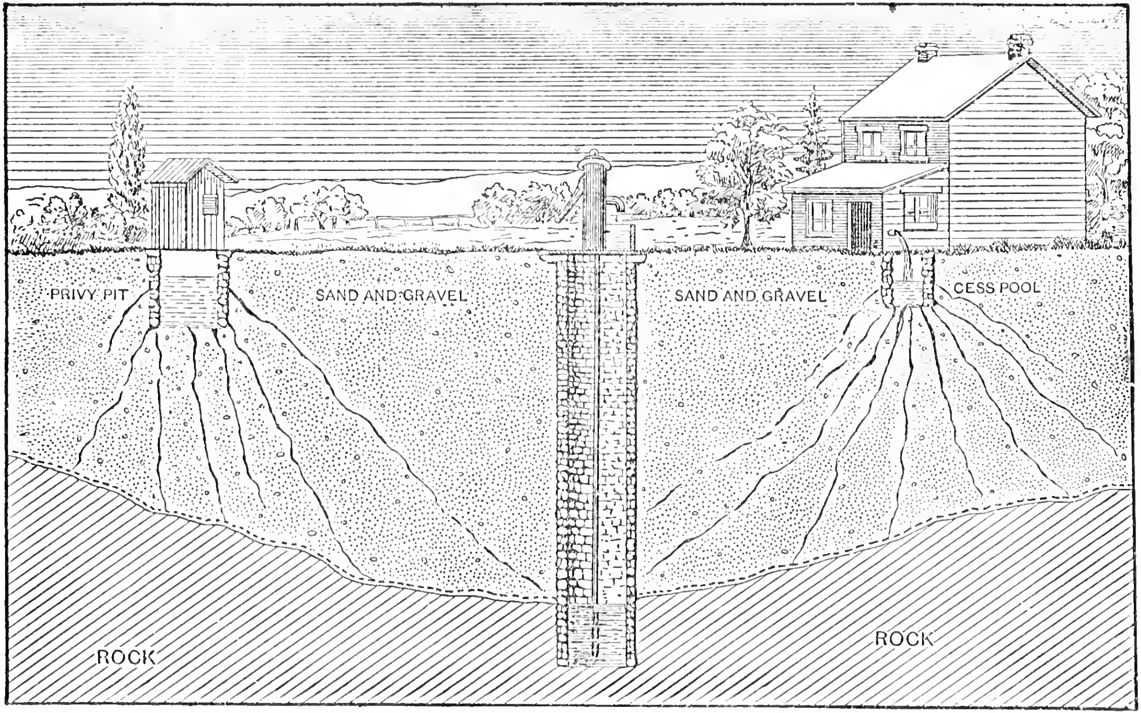


Fig. 59.—Pollution of water by sewage percolating through the soil.

cases where we cannot depend upon a constant supply. The best materials for storage-tanks are iron, masonry properly cemented, or slate. Care must be taken to see that no lead is used either as lining or for cementing joints. Lead poisoning has been known to arise from the lids of cisterns being lined with lead, in forgetfulness or ignorance of the fact that the vapor condenses on the lid, forms distilled water, and drips back with lead in solution, into the cistern. Wood is objectionable on account of its tendency to decay, owing to the alternate wetting and drying; this is especially the case if the cistern is sunk in the earth. If used, the more imperishable kinds, such as cedar and oak, are to be preferred.

537. Plants in tanks are not, as a rule, objectionable, so long as they continue to grow: they rather tend to remove dissolved organic matter from the water. But they die in course of time, and then become objectionable as decaying organic matter. Hence, unless the tanks can be carefully watched, and the dead vegetable matter frequently removed, it is better to keep pure water covered in dark tanks so as to minimize vegetable growth. They should be ventilated.

538. When pipes for the distribution of water are made of lead, the material most commonly used, there is great danger of lead poisoning, especially when the pipes are new. When water has been standing in such pipes for some time it should be allowed to run off. After a time the pipes become lined with an insoluble coating, if the water contains sulphates, phosphates, lime salts or certain earthy substances, or a sufficient amount of carbon dioxide, and not too much of it—(three per cent., or a little over). But if the water is very soft, or contains nitrates, or nitric or acetic acid, or possibly chlorides, the lead poisoning will continue. Iron pipes have been largely introduced of late. They sometimes give a rusty color and a hardness to the water that has been standing in them, and the calibre of small iron pipes becomes lessened with rust, especially if the water contains acids. But, on account of their safety, they are to be recommended. Various other materials have been tried, such as gutta percha, paper, and linings of glass, block tin, enamel, etc., but without much success.

539. The distribution of water takes place either on the constant or intermittent plan. In the latter, the water is turned on at intervals and for limited periods. The objections to this system are that it

necessitates storage in small tanks, with the risk of contamination and the fouling of the tanks with sediment. The dangers of drawing foul air into the pipes (Sec. 229), and keeping confined air in them are also increased.

540. The physical examination of water enables us to form an approximate judgment as to its purity, but this mode of examination cannot be relied on altogether. If a sample of water be colorless, clear, free from suspended matter, transparent, devoid of taste and smell, we may with safety pronounce it good enough for drinking. But it is possible that a certain amount of dissolved organic impurities may elude detection by this method.

541. Turbidity.—Pour the water to be examined into a glass and shake it so as to distribute the suspended matter. Look down upon the stratum of water and observe the depth necessary to obscure printed lines. This may be taken as a measure of the turbidity.

542. Color may be determined by one of the following methods:—

(1) After having allowed the sediment to settle, pour off the clear liquid into a tall glass or into a tube with a glass foot, place it on a piece of white paper and look down through the stratum of water. A depth of eighteen inches to two feet is sufficient to give a fair idea of the color. (2) Two tubes may be used (ordinary test tubes will answer). Pour a sample of the water into one tube, and some pure distilled water into the other. Then place the tubes against a clear white surface and compare the colors. (3) Or a tube may be half filled with the water to be examined, and comparison may be made with the air contained in the remaining half. Vessels made of colorless flint glass should, in all cases, be used in these observations. For slight color the first method is the best.

If a yellowish or brown color is observed, the water may be pronounced impure, or, at least, suspicious. The impurity may be either vegetable or animal organic matter. Vegetable matter or salts of iron may give this color, so that the color does not always indicate the presence of a dangerous impurity. Animal organic matter must, in all cases, be regarded as an impurity rendering the water totally unfit for use either for drinking or cooking. This color should always lead to a further analytical examination of any sample of water. If water is very turbid, and if it is at the same time very dark in color,

it may be at once pronounced unfit for use. A green color does not always indicate impurity.

543. Sediment.—If this is iron its stain or color may be noticed in the vessel. The water flea (*daphnia pulens*) and other living creatures are often present in good waters. The presence of infusoria, bacteria, and microscopical animals of a low type, indicates impurity caused by vegetable or animal organic matter.

544. Taste.—Any water having a bad taste should, as a rule, be rejected and condemned as unfit for drinking or cooking purposes. The agreeable taste of good drinking water is due to dissolved gases, such as carbonic acid. It must be borne in mind that very often water is quite palatable while at the same time it is impregnated with organic animal impurities.

545. Odor.—Pour sufficient of the water into a wide-mouthed flask or bottle to make it about one-third full. Shake it well and notice the odor; if it is unpleasant the water may be considered unfit for use. If no odor is detected the water may be heated to 100° or 110° Fahr. It is best to heat the water by immersing the flask or bottle in hot water. The water should now be shaken again and any odor noticed. If none is perceived a little caustic potash should be added. Any unpleasant odor given off indicates impurity. If a precipitate appears after the addition of caustic potash it is caused by the hardness of the water.

546. Chemical examination must be made, as in the case of milk, if we wish to ascertain positively whether water contains impurities or not, in those cases where a physical examination gives only negative evidence; also if we wish to ascertain the amount and exact nature of impurities. Water may contain (1) dissolved matters which are comparatively harmless, such as salts of lime, magnesia, etc.; (2) substances such as nitrates, nitrites, ammonia, etc., which may be in themselves harmless, but indicate the existence of, or the previous contamination of water by, nitrogenous substances; (3) organic matter derived, it may be, from the resorts or habits of men or from decaying bodies.

547. In forming an opinion as to the character of a water, there are two points chiefly to be considered: (1) The existence of the products of oxidation of organic matter, such as nitrates, nitrites, ammonia, etc., or the existence of compounds which are found in organic matter,

such as chlorides and phosphates. (2) The amount and nature of the organic matter. In inhabited districts we often find the water contaminated with phosphates, sulphates and chlorides; and these are to be regarded with suspicion, inasmuch as they exist largely in waste products of animals. Organic matter may oxidize, forming nitric acid, nitrates and ammonia. Some soils, however, contain sodium, magnesium, potassium or nitrites, and give these up to the water: this must always be borne in mind, and corroborative evidence must be sought to determine the sources of these compounds. There are also other questions in the chemical examination of water which are of minor importance in estimating its character from a sanitary standpoint: (1) The amount and nature of purgative salts and such other saline constituents as do not indicate the presence of organic matter. (2) The degree of hardness. (3) The existence and amount of metallic substances. In judging the sanitary qualities of a water a certain proportion of impurities may be considered harmless, but this proportion must be small.

548. **We may therefore state a standard of purity** for water, beyond which all waters must be considered suspicious, impure and unfit for use:—

Total solids	15	grs.	per gallon.
Chlorine	1	"	"
Free ammonia	.005	"	"
Albuminoid ammonia	.001	"	"

The amount of ammonia which may be permitted is so small that, in Nesslerizing (Sec. 555) without distillation, the slightest trace is sufficient to condemn the water. Albuminoid ammonia is a measure of the nitrogenous organic matter in water, and it may be estimated by converting the nitrogen into ammonia by means of re-agents.

549. **For sanitary purposes water may be divided** into three classes: (1) Water containing less than .005 grains per gallon of free ammonia, comprising (*a*) pure distilled water, (*b*) deep spring water, (*c*) pure lake water, (*d*) best river water, fed from mountain springs, and uncontaminated in the flow; (2) water containing between .005 and .01 grains per gallon of free ammonia, and comprising ordinary water supplies; (3) waters containing over .01 grain per gallon of free ammonia.

550. Qualitative analysis is the mode which enables us to determine the impurities present in a water without reference to their relative proportions. For ordinary purposes this method is sufficiently accurate if carefully conducted. In the majority of cases it will afford information which may enable us to form a reliable opinion regarding the character of water.

551. Quantitative analysis is the process by which are determined not only the nature of the organic impurities, but also the amount of each and their relative proportions. In all cases in which a qualitative examination indicates that water is doubtful or suspicious, and in all cases in which legal proceedings or the enforcement of sanitary law may become necessary, it is better to have a quantitative analysis. A quantitative analysis should also be made of any water intended for a public supply.

552. All test tubes and other apparatus used should be chemically clean; otherwise inaccuracies will occur. In order to determine the character of a sample of water by qualitative analysis it is necessary to test for the following substances at least:—(1) ammonia, (2) nitrites, (3) chlorides, (4) organic matter.

553. The following solutions are required:—

(1.) Solution of nitrate of silver: pure nitrate of silver, 4 grains; distilled water, 2 ounces.

(2.) Permanganate of potash solution, in the proportion of 1 grain to 6 ounces of distilled water.

(3.) Iodide of potassium solution: potassium iodide, 10 grains; distilled water, 2 ounces.

(4.) A solution of boiled starch freshly prepared at the time of testing, containing about 2 grains to the ounce of distilled water.

(5.) Sulphuric acid re-distilled and chemically pure. Ordinary commercial sulphuric acid may give false results.

(6.) Nessler's solution. This is used as a standard solution for volumetric analysis, and must be carefully prepared. Dissolve 30 grains of iodide of potassium in half an ounce of pure distilled water; dissolve 15 grains of corrosive sublimate in another half ounce, heat if necessary, and allow the solution to cool. Add the corrosive sublimate solution to the iodide of potassium solution until a perceptible permanent precipitate is produced, then dilute with a solution of caustic

soda (of the strength of 24 grains of soda to the ounce) up to 2 ounces; add corrosive sublimate solution until a permanent precipitate again forms; allow the precipitate to settle, and then decant off the clear solution.

554. In proceeding to make an examination of water it is well to test its re-action with litmus and turmeric papers. Water is usually neutral or nearly so. If litmus paper turns red, denoting acidity, and the acidity disappears on boiling, it is due to carbonic acid. If alkaline, and the alkalinity disappears on boiling, ammonia is indicated. If the alkalinity is permanent, it is due to sodium carbonate. Negative evidence obtained in this way is of no value, but the positive evidence may be.

555. To test for ammonia pour some of the water to be examined into an ordinary test tube, and add 4 or 5 drops of Nessler's solution. If a yellow or yellowish-brown color or precipitate forms, ammonia or ammoniacal salts are indicated. This should be regarded as a very suspicious manifestation. If the precipitate is considerable or the color distinct, the water may be considered impure. However, the color may be obscure from an excessive milky or curdy precipitate, owing to the hardness of the water. In this case, if the yellow color cannot be observed after standing a few hours, a distillate may be made and tested as before.

556. Nitrites.—Pour some of the water into a test tube, add 5 or 6 drops of pure sulphuric acid, then add a few drops of the iodide of potassium solution (also chemically pure), next pour in a little starch solution, freshly prepared with distilled water. If a blue color immediately appears, the water is impure. A deep blue color indicates very impure water. In this test a comparative experiment should always be made with pure distilled water, as iodide of potassium sometimes contains iodate, and sulphuric acid generally contains traces of oxides of nitrogen.

557. Chlorides.—Add a few drops of dilute sulphuric acid (chemically pure), and then some of the nitrate of silver solution. If a distinct white precipitate appears, changing to a lead color, it denotes impurity. A slight turbidity or milkiness does not indicate sufficient impurity to condemn the water. If the water is from a source rich in salt, it may yield a precipitate and still be free from pollution.

Absence of chlorides in a water is partial evidence of purity, especially if, after standing an hour, the water remains colorless.

558. Organic matter.—Fill a four-ounce flint-glass phial or other vessel with the water to be examined. Then add a drachm of the solution of permanganate of potassium, and a pink color will be at first imparted. Fill another phial or vessel with pure distilled water, and add a like quantity of permanganate solution in the same manner. Place the two glasses side by side on a sheet of white paper, and note any differences in the shades of color. If decoloration rapidly proceeds the water may be considered impure. The amount of oxidizable organic matter may be estimated by the rapidity of change from pink to brown. The permanganate test will show by rapid decoloration that oxidizable matters, and hence nitrites, are present, so that if this test is carefully made the sulphuric acid and potassium iodide test (Sec 556) may be dispensed with.

559. In a pure water containing iron, a similar change from pink to brown may occur, or it may be caused by the presence of nitrites or sulphuretted hydrogen. The latter may be detected by its odor. The presence of iron may be judged by a reference to the source of the water or by appropriate tests. The presence of nitrites can be ascertained by tests before mentioned.

560. The practical deductions which may be drawn from these tests are exhibited in the following table, based on one contained in Parkes' "Manual of Practical Hygiene," and modified so as to apply to the qualitative tests given in this work :—

Ammonia.	Nitrites.	Chlorine.	Remarks.
Nil.	Nil.	Slight.	Pure.
*Nil.	Nil.	Marked.	Good.
Trace.	Nil or trace.	Marked.	Suspicious.
Marked.	Nil or trace.	Marked.	If containing also sulphates, phosphates and nitrates, may be a shallow well contaminated with urine.
Marked.	Marked.	Marked.	Contaminated with sewage.

* By the tests given.

If nitrites are detected at first and after a few days disappear, their disappearance may be attributed to oxidation into nitrates. If after a few days nitrates disappear, this change is probably owing to the rapid increase of bacteria, or other low forms of life.

561. If water is allowed to stand until a sediment forms, and the supernatant fluid is poured off, or if the water is filtered, and found, upon carefully testing the clear liquid, to contain no traces of ammonia, nitrites, or chlorides, it proves that the water is usable, but the well from which it was obtained should be cleaned out; if not, the water should be filtered, and the contents of the filter frequently changed.

562. A water containing a large amount of salts will probably yield a large flocculent precipitate with Nessler's solution. If it does not become tainted, and does not give any indication of the presence of nitrites or organic matter, it may be considered a hard water and fit for use.

563. When an excess of nitrites and nitrates is manifested, and Nessler's solution produces no discoloration, water should be regarded with suspicion. It thus proves that organic matter has been present and that oxidation has taken place. In such a case a careful quantitative analysis should be made.

564. The injurious effects of very hard waters, or waters containing various salts in excessive amounts, are often seen in the impairment of the digestive functions. It has been found that water (or baking powders) containing large proportions of calcium sulphate and chloride, or magnesium salts, may induce loss of appetite, slight nausea and other evidences of indigestion, also constipation, with occasional diarrhœa. Water containing nitric acid, or its compounds, is also liable to produce dyspepsia. Brackish water, containing a large percentage of sodium chloride (table salt) may give rise to diarrhœa. This affection is also caused by suspended earthy matters in water. Waters containing mineral ingredients are supposed by some practitioners to be one of the causes of calculi. Goitre is prevalent in regions where the water contains a large quantity of lime.

565. Water containing metallic impurities, such as lead, zinc, copper, iron or tin, may give rise to symptoms of colic and other disturbances of the stomach and bowels. Lead causes paralysis also. Water

acquires impurities of this class chiefly from pipes and vessels in which it is contained (see Secs. 536 and 538).

566. Water contaminated by animal and vegetable substances may cause vomiting, cramps, severe purging, diarrhœa or dysentery. The propagation of infectious diseases by contaminated water has been considered in Chapter X. Impure water, though not containing the germs of contagion may, nevertheless, add to the malignancy of infectious diseases. Drinking-water polluted by the drainage from graveyards is very dangerous. Marsh waters may produce fevers and diseases of the liver and spleen.

567. Entozoa, or parasites, may be introduced into the system in drinking-water (see Sec. 442). Dr. Paterson, an eminent physician of Leith, noticed that certain families who drew water from a public well in a particular street were subject to intestinal worms; the families at the other end of the same street, who used the pure water which is supplied to Edinburgh and its vicinity, were free from the parasite. The suspected water came from a dirty pond or lake in the neighborhood, and contained numerous vermiform animalculæ. Many other instances are on record of these and other parasites being taken into the system in drinking-water. Small leeches introduced in this way have been known to give rise to cough, nausea and spitting of blood.

568. For the purification of water four principles are employed: keeping the water in a state of rest for a sufficient length of time to allow of the *settling* of impurities, the water being then drawn off from them; the addition of substances which will cause *precipitation;* the *filtering*, or straining out of impurities; the exposure to influences, or the addition of substances, which, by chemical action, will use up impurities in the formation of *innocuous compounds.*

569. Of the settling of turbid water we have common experience on the small scale, when we allow a jug of muddy water, or water containing particles of sand or other suspended impurities, to stand till it becomes clear. Water companies often use large settling tanks or settling basins for the same purpose. Two or more tanks may be employed, especially if the constant plan of distribution is in operation.

570. Among substances used for removing impurities we may mention alum, salts of iron, tea, and other astringents, which entangle and

precipitate suspended impurities. In eastern countries the bean of the *strychnos potatorum* is used for the same object. Lime carbonate held in solution by an excess of carbon dioxide may be precipitated by the further addition of lime, or by adding sodium or magnesium chlorides or carbonates, or alum. Potassium permanganate, coke, charcoal, and other like substances, have been used to oxidize organic matter; the chemical action of charcoal, however, is very slight. Methods of precipitation by the addition of various substances is little employed on the large scale: they may be serviceable as temporary expedients when such waters must for a time be used, as in travelling and camping.

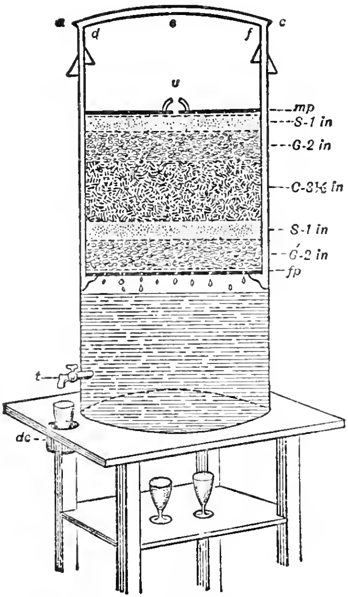


Fig. 60.—Domestic filter: *a*, *c*, upper edge of outer case; *d*, *e*, *f*, inner case containing the filtering materials—this case may be lifted out, to change its contents and to cleanse the reservoir beneath it; *m*, *p*, a movable plate, impervious except immediately beneath *u*, the perforations being surrounded by a little raised wall, so that settlings will not be drawn through the openings; *S*, *G*, *C*, *S*, *G*, layers of sand, gravel, charcoal, sand and gravel of the depths indicated; *f*, *p*, is the fixed bottom plate of the inner case, which rests on shoulders in the outer case; *t*, tap to draw off the filtered water.

571. Filtration, either alone or in conjunction with settling tanks, is the most common method of purification; it may be practised either on the small or the large scale. Sand, gravel, powdered coke, charcoal and spongy iron are the substances most commonly employed in filters, whether large or small; and in small filters, sponge, wool, flannel, charcoal blocks, porous stones, magnetic iron ore, and manganic oxide.

572. Of domestic filters, one of the best is that shown in Fig. 60, which is fully described in the note accompanying it. In one of the filters in which sponge is used an impervious earthenware plate separates the unfiltered from the filtered water, the only channel of communication being through a little cavity similar to that immediately beneath the letter *u* in Fig. 60, and this little cavity is filled by a sponge.

573. A small tank-filter for household use is shown in section in

Fig. 61. It will be seen that the mode of filtration is upward, the water passing up through the filter when any tap is opened to draw off water for use. This tank is a settling tank as well, the heavier particles falling on the bottom of the tank, and not increasing the deposit on the filtering material.

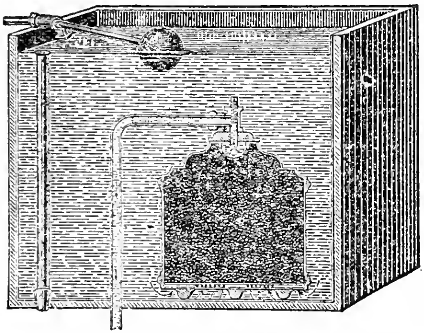


Fig. 61.—Small tank-filter, upward filtration taking place when taps are opened.

574. Of small faucet filters, to be screwed on to taps, there are several varieties. They are generally filled with quartz sand; sometimes charcoal is added. They are all made so as to be reversed for the purpose of cleansing them. There is one kind in which this can be effected without unscrewing the filter: it consists of a hollow globe, inside of which is another globe filled with sand; this inner globe can be revolved and reversed by turning a handle.

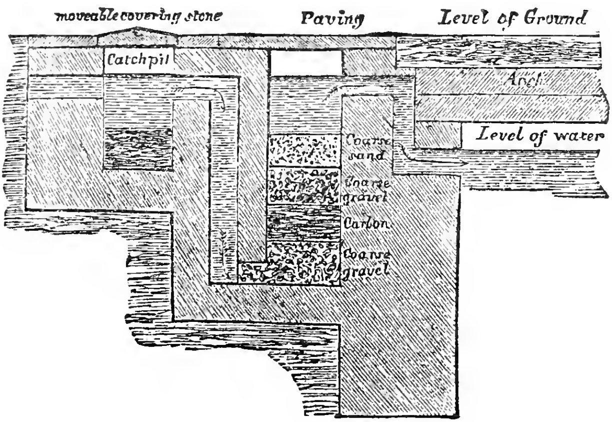


Fig. 62.—Filter with catch-pit and tank.

575. Filters on the large scale are used either alone or in connection with settling-basins. In the latter case, after the subsidence of the

heavier suspended matters, the water is run off from the settling-basin into the filtering-basin, from which it generally passes to a storage-tank or reservoir. In Fig. 62, a slight modification of this plan is shown, a catch-pit being substituted for a settling-tank; the filtration is upwards in this instance. More commonly we have downward filtration through layers of sand, gravel and coarse stone in succession from above downward. Tiers of brick with interspaces are sometimes substituted for the stone.

576. **The chief benefit of filters** is the removal of suspended impurities. They exert very little influence on dissolved impurities, especially after they have been a short time in use, as the materials are soon robbed of any power they possessed in this direction. When they are allowed to rest long enough for the water to be entirely drained off, and air to enter in its place, the latter exerts an oxidizing effect, and, for this reason, alternate or intermittent filtration is beneficial. Germs of disease are not easily filtered out of water.

577. **Filtering materials should be frequently changed,** otherwise they become worse than useless: the organic matter which they have retained decomposes, and renders the water passing through them more impure, instead of improving its quality. Hence, some authorities recommend persons not to use water from a filter, unless they know that care is taken to change its contents frequently. In filters on the large scale a few inches of the top layer may be changed often, and the deeper layers at longer intervals. In one city in this Province good water was rendered impure by filtering through a sand-bank containing constant accessions of organic matter; the filtering basin, constructed at great cost, had to be abandoned.

578. **A large filter with mechanism for washing the contained sand,** or other filtering agent, free from impurities, is now in use at the Kingston Asylum for the Insane, and many other places on this continent. It is called the Hyatt Filter (Fig. 63). It consists of two compartments: the water is filtered (downwards) through a bed of sand, or sand and charcoal in the lower compartment. When it is considered desirable to wash the sand, it is carried with a rush of water through pipes and allowed to fall through a body of water in the upper compartment; when it has all settled in this compartment it is allowed to fall down again through water in the lower compart-

ment, and as soon as it settles the filtration may be re-commenced. This cleansing process occupies from ten to twenty minutes, and may be performed once in twenty-four hours, or more often if desired. In the small cylinder to the left a plug of iron chloride and alum may be made to act to any desired extent on the water going to the filter, thus causing a precipitation of impurities (as described in Sec. 570); these are then strained out by the filter bed.

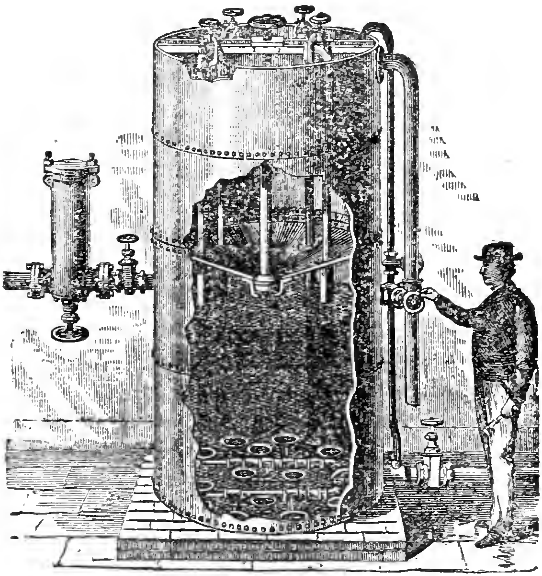


Fig. 63.—Hyatt Filter.

579. Boiling, and the use of contrivances for exposing it to air, are other means for the purification of water. Boiling coagulates some of the organic matter, precipitates some of the impurities and drives off others in gaseous form. Impurities may be oxidized by agitating the water or making it fall through air, imitating the action of waves and of natural rapids.

580. Freezing does not render impure water harmless: numerous instances are on record of outbreaks of disease from the use of ice obtained from impure sources.

581. Drinking-water for schools should be kept perfectly free from any suspicion of contamination. In places where the water supply is procured from wells, trustees or school authorities should have absolute control of them. In no case should schools be supplied from wells on neighboring grounds controlled by private individuals. Wells should be located at least eighty feet from the school-house, and a greater distance from outhouses. The wall of the well for some distance below the ground should be impervious to surface leakage, and it should extend a foot above ground. Around the pump there should be a close, tight-fitting platform, covering the well. Air may be admitted through a tube placed beside the pump and extending some distance above the platform. The well should be emptied and cleaned out at frequent intervals, and the pump should be kept clean. A trough should be so placed as to carry the drippings from the pump a sufficient distance away from the well. An open well, with a windlass for drawing up the water in a bucket, is preferable to a close well with an ordinary pump—more perfect aeration of the water can be maintained in this way. The ordinary potass-permanganate test (Sec. 558) may occasionally be applied, in order to detect any impurities that may exist. No cistern or tank for storing water should be allowed near the well.

Earthen vessels are less likely to become unfit for keeping water in than wooden or tin pails. Drinking cups should be of earthenware, china or glass, and should be kept clean. Care should be taken to see that the glazing of earthenware is not of such a character as to impart metallic impurities to the water; with this precaution, vessels glazed inside, so as to be smooth and easily cleaned, are very good. They should be covered, and should have proper taps for drawing off water, so as not to permit dust to enter, as it often does in open pails. In summer means should be taken to have the water cool.

CHAPTER XVII.

THE EYE: ITS STRUCTURE—BLIND SPOT—FORMATION OF IMAGES—ACCOMMODATION TO NEAR AND DISTANT OBJECTS—SINGLE VISION—NEAR-SIGHT—FAR-SIGHT—CONFUSED SIGHT—SQUINTING—REMEDIES WHICH SHOULD BE APPLIED—CARE OF THE EYES—PROPER AND IMPROPER POSITIONS OF WINDOWS—PAPER AND TYPE—STATISTICS OF NEAR-SIGHT—INJURIOUS MODES OF READING—OCCUPATIONS—COLOR BLINDNESS.

582. The eyeball (Fig. 64) is spherical and nearly an inch in diameter. It consists of transparent media contained within certain enveloping coats or tunics.

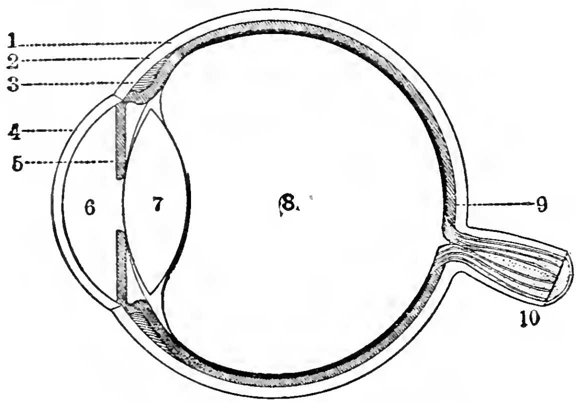


Fig. 64.—Antero-posterior section of the eyeball.

583. The cornea and sclerotic constitute the outer coat. The cornea, or "glass of the eye"(4), a transparent membrane, is set, like a watch glass in its frame, into the anterior circular edge of the sclerotic membrane, or "white of the eye" (1). These membranes are of tough, firm, and composite—largely fibrous—texture.

584. The choroid coat (9) lies on the inner surface of the sclerotic. It consists of a network of blood vessels bound together by loose connective tissue, the interspaces being filled with pigment. The tissues of the choroid become thicker in front from certain folds of the *ciliary processes*, and, extending on to the point of junction with the cornea, stretch across behind, and at some distance from, the latter, in the form of a curtain.

585. The iris (5), as this curtain is called, has in its centre a circular opening, "the pupil" (see Fig. 58, p. 182). The pupil becomes smaller when the eye is exposed to a bright light, and larger in a dim light. The contraction and dilatation of the pupil are due to the action of muscular fibres in the iris, named respectively *circular* and *radiating* fibres. It will be seen from the description given that no light can enter the eye except through the cornea, that none can pass beyond the pigment-laden curtain of the iris, except through its central opening, the pupil, and that by the action of the two sets of muscular fibres of the iris, the amount of light passing through the pupil is increased or diminished.

Another small but important set of muscular fibres—the *ciliary muscle* (3)—is situated at the point where the iris and ciliary processes join, forming with the latter the *ciliary body*. The muscular fibres of the iris and the ciliary muscle are *involuntary*, not being under the influence of the will. (See Chap. XX.)

586. The retina, the third and remaining coat, lies upon the inner surface of the choroid. It consists of several layers: one of the most anterior is the layer of optic nerve fibres, an expansion of the *optic nerve* (10), a large nerve which, passing from the brain, and through the cavity or socket which contains the eye, pierces the sclerotic and choroid coats, its fibres then spreading out in a thin layer upon the choroid; one of the outer layers is that of the *rods and cones*, consisting of minute columns: this layer receives impressions and images and transmits them to the layer of nerve fibres, by which again they are conveyed to the brain. The spot where the optic nerve pierces the sclerotic, and from which its fibres branch, is destitute of the covering of rods and cones, and hence is fitly called *the blind spot* of the retina.

587. The phenomenon of the blind spot may be shown by the follow-

ing experiment: cover the right eye with the hand, and keep the vision of the left eye fixed upon *B*. Move the page back and for-

A——————————————————B

wards, to and from the face, *always keeping the left eye directed toward B:* it will be found that at a distance anywhere in the neighborhood of six inches *A* will be visible; as the page recedes from the face, a point will be reached at which *A* will be lost from view, and at a still greater distance it will re-appear. The point at which it disappears will be that at which rays from *A* fall on the blind spot of the eye.

588. The humors of the eye are, proceeding from before backwards, (*a*) the *aqueous humor* (Fig. 64, 6) filling the *anterior and posterior chambers*, between the cornea and the iris, and between the iris and crystalline lens, respectively. Immediately behind the circular free edge of the iris and the aqueous humor is (*b*) the *crystalline lens* (7), a body semi-fluid in infancy, and becoming pretty firm after the prime of life has been reached; convex on both surfaces, but more so anteriorly, it is enclosed in a capsule, and is held in its central position by the *suspensory ligament*. Behind the lens again we find (*c*) the *vitreous humor* (8), which forms about four-fifths of the bulk of the eye. The globe of the eye, which has been thus briefly described, is situated in the cavity of the orbit, together with the blood-vessels which supply it, the optic and other nerves, the lachrymal apparatus, (by means of which its anterior surface is kept moist and free from dirt and other intruding particles), the muscles (Fig. 65) which turn it in all directions towards various objects in the field of vision, and more or less fat. The muscles to which we have just referred, although they sometimes act under instinctive impulse, are yet of the voluntary class. The eyeball is lubricated, and at times closed in, by the eyelids, which protect it, and keep its surface moist by repeated momentary closure.

589. Formation of images on the retina.—The eye may be likened to a camera, the retina being its sensitive plate, on which are photographed the images of objects by means of the rays of light reflected from them. These rays are imaginary straight lines proceeding from every point of a luminous or illuminated object. It is evident that

the rays from any such point will proceed in all directions until intercepted by some opaque object.

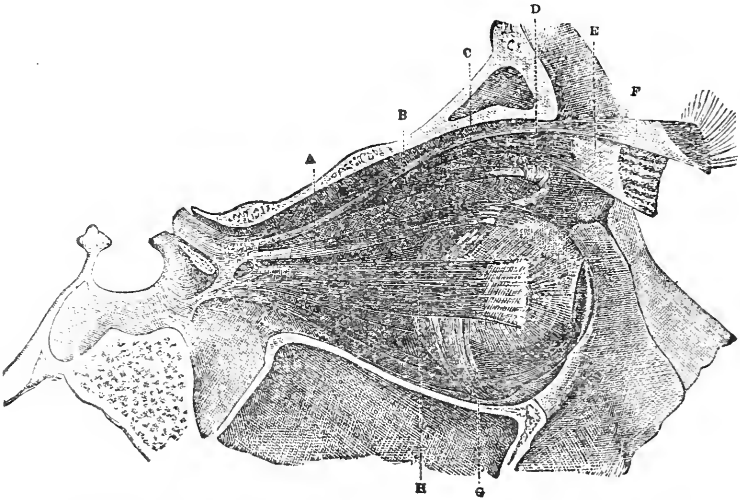


Fig. 65.—The muscles of the right eye. *A*, superior straight; *B*, superior oblique, the tendon of which passes through a pulley, *D*; *G*, inferior oblique; *H*, external straight, and, beyond it, the internal straight muscle; *C*, *E*, *F*, muscles of the upper eyelid.

590. Hence there will be a number of divergent rays from each point. If we take a certain limited space on which such rays are to fall, it will be manifest that this space will collect a smaller number of rays if it be removed to a greater distance from the luminous point than it will if nearer to the point; but that at that greater distance the rays falling upon it will be more nearly parallel: in Fig. 66 the screen *S*, when brought to the position *X*, receives the rays 1

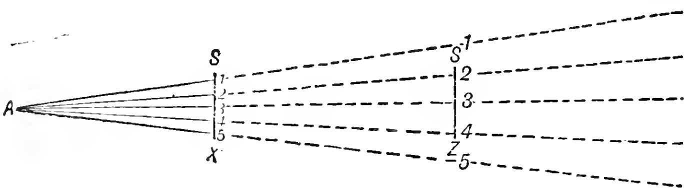


Fig. 66.

to 5; when removed to the distance *Z*, it only receives the rays 2 to 4, but at the extremities of the screen, at *Z*, 2 and 4 are, of course,

more nearly parallel than 1 and 5 are at the same portions of the screen at X. Rays entering the eye at a distance of twenty feet or more are, as regards vision, considered practically parallel. But even parallel rays—a multiplicity of rays—from different points of the same object, intermingling, would produce a confused image, or really no image at all.

591. **To bring to a focus** at one point on the retina the pencil of rays passing through the pupil from an objective point, is necessary for distinct vision. Each point of the object having its corresponding point on the retina, a distinct image will be formed. Rays passing through the cornea, which is the principal refracting surface, are brought to a focus through the further refraction of the media, more especially of the crystalline lens. This is illustrated in the above diagram.

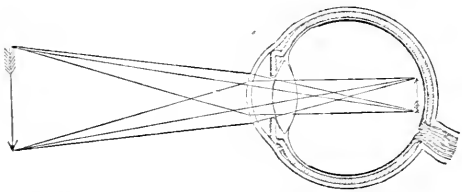


Fig. 67.—Diagram showing how the rays from each point of an object are brought to a focus on the retina, a distinct image of the object being thus formed on it.

592. **If a refracting apparatus of exactly the same power** be used for near and distant objects, it is evident that if the rays from the distant object are brought to a focus on the retina, those from the near one will not be brought to a focus before reaching it; on the other hand, if those from the near one be brought to a focus on the retina, those from the distant one will be brought to a focus in front of it. This will be made plain by a reference to Fig. 68, in which it will be seen

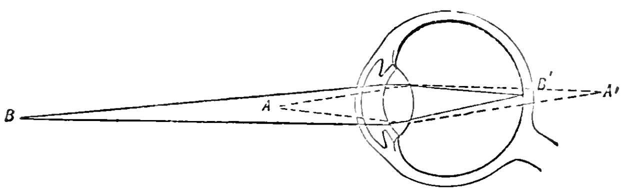


Fig. 68.—Diagram showing that the same refractive power will not bring to a focus at the same point the rays from near and distant objects.

that the rays from the point B, after passing through the lens, converge to meet at the point B', on the retina, whilst those from the nearer point A do not meet where they strike the retina, but if

they could continue on through the retina, would meet at a point *A'* behind it. In order that the rays from *A* may be brought to a focus at the retina it will be necessary to increase the thickness and convexity of the lens, as shown by the dotted curved line in Fig. 69, indicating the wall of a lens so changed; the dotted rays are the same as in the preceding figure, and the uninterrupted lines behind the lens indicate the converging rays meeting on the retina at *C*, after passing through the more convex lens.

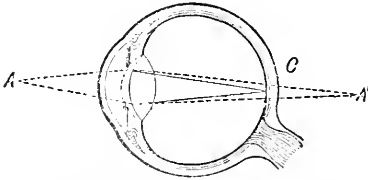


Fig. 69.—Diagram showing increase of refraction by increased thickness of the lens.

593. **This process of accommodation,** as it is termed, is exactly what occurs in the normal eye. When the eye is in a state of rest (*A*, Fig. 70) rays coming from a point distant twenty feet or more will be brought to a focus on the retina by the refractive power before alluded to. To bring to a focus rays from objects at a less distance, the ciliary muscles are brought into play: they cause a relaxation of the suspensory ligaments, and (*B*) a consequent increase in convexity of the lens, from its own elasticity, whilst at the same time the lens and free margin of the iris are pushed a little forward and the pupil becomes smaller. Now, the abuse of this little muscle by putting on it too much of this work, is one of the things we have to guard against. Before proceeding to draw hygienic deductions from the explanations just given, let us consider

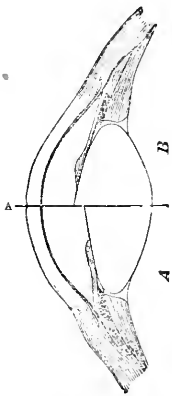


Fig. 70.—Diagram illustrating the mechanism of "accommodation."

594. **How both eyes are directed** so that the retina of each views the image of the same object, and the impression of one object is transmitted to the brain. This is accomplished by the action of the muscles which rotate the eyeball (Fig. 65), and which direct the axis of each eye towards the object, so that the image may fall upon the limited portion of the retina which is most capable of receiving impressions, and on those portions of it which correspond, and will produce the same and, therefore, a single, impression. The

images in the eyes will be from slightly different positions, thus producing the stereoscopic effect of bodies in relief.

595. The optical defects of most common occurrence are *near-sight*, or *myopia ; far-sight*, or *hypermetropia ;* and *confused sight*, or *astigmatism*. Greater accuracy of expression would be attained, and less room left for fallacious suppositions, if the first were called want of far-sight, and the second want of near-sight.

596. In near-sight, or myopia, the axis of the eye from before backwards is so long that the rays, after passing through the lens, arrive at a focus before they reach the retina. In Fig. 71, the line *a, e, c, g*, represents the contour of the myopic eye ; *a, b, c, g*, being that of the normal eye. Now, if the distance, *g, b*, is that at which parallel rays—those from a distance (see Sec. 590)—will be brought to a focus, then it is evident that they cannot come to a focus at the distance of *e*, there being no natural means provided for making the rays more divergent and causing them to converge at *e*, nor for sufficiently reducing that distance. To overcome this defect, short-sighted persons are in the habit of half closing the lids, a practice which has given rise to the term "myopia."

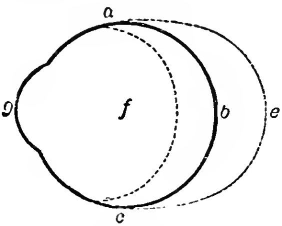


Fig. 71.—*a, b, c, g*, contour of the normal eye ; *a, e, c, g*, that of the myopic ; *a, f, c, g*, that of the hypermetropic.

597. In "far sight," or hypermetropia, the shape of the eye is that indicated by the line *a, f, c, g*, in Fig. 71. Here, by a process of reasoning similar to that employed in speaking of myopia, it will be

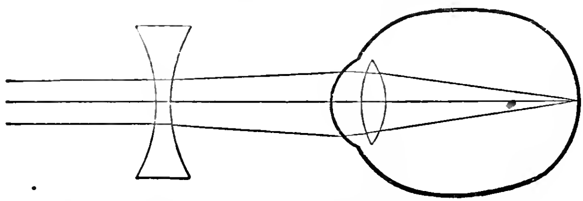


Fig. 72.—Action of a concave lens on rays entering a myopic eye.

seen that without an excessive convexity of the lens, such as cannot be obtained by the natural means described on the opposite page, the focus cannot be at the retina. When the attempt is made

an excessive strain is in many cases brought to bear on the ciliary muscles especially, and, to a certain extent, on the external muscles of the eyeball.

598. The artificial aid of lenses will remedy the difficulty in each of these cases. In myopia a concave lens will increase the divergence of rays, as shown in Fig. 72. In hypermetropia a convex lens will increase their convergence, as in Fig. 73.

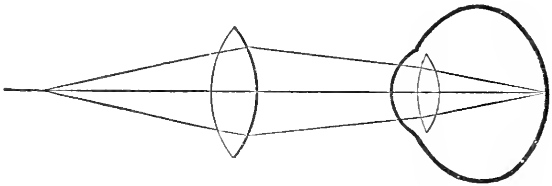


Fig. 73.—Action of a convex lens on rays entering a hypermetropic eye.

599. The condition of "old sight," or presbyopia, is often classed indifferently with that of hypermetropia, both being relieved by convex lenses. But the former may occur in myopic as well as in hypermetropic eyes, and is owing to the fact that the lens being more dense and less elastic in old age, it will not become sufficiently convex and thickened under the action of the ciliary muscle, so that rays from a near point would come to a focus behind the retina.

600. Confused sight often arises from a defect called astigmatism in eyes in which the curvature of the cornea is abnormal, the fault being generally in its vertical plane. The pencils of rays in planes at right angles to each other have different focal distances from the cornea; those in one plane may come to a focus at the retina, and those in the other behind it, or the one in front and the other on it, or both in front (unevenly myopic), or both behind, or the one in front and the other behind.

601. The result of astigmatism is to produce differences in the distinctness of equal lines which have different directions in relation to the horizontal and vertical planes. Any person with a normal eye may illustrate this for himself by looking at the letters on a page through a cylindrical rod, such as the glass mixer of the druggist. Holding the rod horizontally, he would have difficulty in distinguishing, for example, between n and u; holding it vertically, the difficulty

would be as between m and n. In order to overcome the difficulty, the astigmatic eye frequently and rapidly changes the accommodation (see Sec. 593), and hence is apt to become soon tired.

602. We may correct the defects of astigmatism by cylindrical lenses, or by a combination of these with glasses for myopia or hypermetropia. It would be interesting to consider the various combinations, but we have not space; our object being rather to draw the attention of people, especially of teachers, to these defects, and to point out how they may resort to rough preliminary tests, and refer for more precise details to an oculist, if found necessary.

603. A few test types will be found on the last page of this work. These are used for the purpose of ascertaining whether the sight is defective, the distances, in feet, at which the various lines should be read by the normal eye being indicated.

604. Weak-sightedness, or asthenopia, consists in an inability for continuous use of the eyes without pain or other unpleasant symptoms. This often arises from some of the defects already described, and sometimes from weakness of the ocular muscles; it should not be neglected, even if the sight seems excellent.

605. Squint, or strabismus, arising from irregular action of the muscles which move the eyeball, is frequently caused in the same way. We are principally concerned with its prevention; but, inasmuch as its continuance is liable to give rise to disease of one of the eyes, to the gradual loss of vision in it, and to the consequent impairment of the usefulness of the scholar or other individual, it is a matter of importance from a hygienic point of view that the squint be remedied, (whether caused as above indicated, or by convulsions, partial paralysis, or congenital defect), and that the operation of dividing the little muscle be not deferred indefinitely.

606. Care of the eyes in infancy.—It is well known to those who have to do with new-born infants, that they are very liable to "sore eyes"—inflammation of the *conjunctiva*, the soft, moist, lubricating (mucous) membrane which lines the lids and covers the front portion of the white of the eye. These affections are very apt to be neglected for some little time, under the supposition that it is not well to interfere with such little matters in childhood, and that they will rectify themselves. Great and permanent injury is frequently the result.

607. With regard to the exposure of the eyes to light, two opposite errors are committed. Some persons thoughtlessly expose the eyes of children to a glare of light which they would after a time find trying to their own eyes; nor is it sufficiently borne in mind that the eyes of the infant have not been accustomed to the light: the sensibility of the retina becomes impaired or destroyed by undue exposure. The opposite error is that of placing coverings on the face to screen the eyes from the light; whilst one object is secured, fresh air is kept from the respiratory passages, with the injurious results described in Chap. III. The means of screening the face or softening the rays of light coming to the child will be so obvious, that we need not do more than draw attention to the subject.

608. When infants begin to look at near objects, they bring them, if they can, very close to the eyes, the convergence of which becomes so great that it is apt to induce squint. They should not be allowed to hold objects so very near to the eyes.

609. In children, even when past the age of infancy, inflammation of the lids, purulent ophthalmia and ulcerations of the cornea are frequent, and they are liable to be overlooked and neglected, especially if the child has not arrived at an age to use the eyes for purposes of systematic study or work. The remarks which have been made regarding the folly of such a course are equally applicable here.

610. That purulent ophthalmia is communicable must not be forgotten. The greatest care should be taken to guard against such communication; each child should have his own towel, basin, etc., and use no other. In some institutions where the disease may spread no basins are provided, water being used from a running tap. When only one eye is affected, it should be remembered that the discharge may inoculate the other eye, if care be not taken.

The child has now grown to that age when he will instinctively protect himself from the glare of intense light; but he, as well as the adult, may still expose the eye unnecessarily, from not having thought sufficiently on the subject; the amount of immediate annoyance may be less, but continuous, and injurious on account of its continuance.

611. If a flood of light, or too bright a light, be allowed to fall upon the retina, the excessive stimulus impairs its sensibility; and the

diffuse light also interferes with the impression which would otherwise be produced from an object we wish to see. When we want to look at an object we should keep the optic camera—the interior of the eye—comparatively free from direct light, and reserve it for the reception of rays from the object or objects to be looked at, and these should be sufficiently illuminated to produce the desired effect of distinct vision. In such a case, then, it is obvious that the respective positions of the eye and the light should be such that the light shall fall on the object and that the eye shall be shaded. If the object is one which will reflect rays very brightly, the effect may be somewhat similar to that produced by direct light in too great quantity or too bright. Again, if light falls from opposite sources on an object, we may have confusion from reflection of the "cross-lights."

612. We often find scholars facing the windows, a flood of light entering their eyes, the teacher thrown into the shade between them and the windows, the blackboard placed somewhere in the neighborhood of the teacher's desk, sometimes between the windows; or the blackboard may be a bright reflecting surface, and so placed that a dazzling reflection reaches the eyes of the scholars. Let us now watch the latter at their various employments. Some have their books flat on the desks, so that the light may fall on the page, and their heads are bent forward so as to shade their eyes from the light. This position is very bad both as regards respiration and the condition of the spinal column, brain and nerves. The free return of blood from the brain, and from the eye itself, is interfered with. Others are turned half around in their seats, or have the upper portions of their bodies twisted into the same position, having found by gradual experience the benefit to be derived from a side light. Others are straining the muscles of the eye and eyebrows, and are suffering from the strain of the involuntary muscles of the iris, in the effort to exclude the excessive amount of light and receive the impression of the rays from the dimly-illuminated face of the teacher or surface of the blackboard. The effects of this constant or oft-repeated strain, and of the constrained postures just described, are pain in the eyes, headache, dizziness, flushed face, pain in the back and shoulders, and other symptoms of weariness or uneasiness.

613. In another room the light falls from behind. For reading, the

pupil may make this light answer by holding up his book, at the expense of obscuring the teacher's face, or his own face from the teacher; in writing, ciphering, drawing, and other like occupations, his own shadow will seriously interfere and cause him to stoop over and strain his eyes to see.

614. **In rooms in which light comes in from the right side** the shadow of the hand falls upon the portion of the page at which the pupil is looking. We have already spoken of the bad results of cross lights, and yet many of our schoolrooms are lighted in this way. The best light is that coming from the left side, and, if anything, a little in front.

615. **The light should come somewhat from above;** the bad results of any deviation from the proper horizontal direction, especially if that deviation is toward the front, are somewhat lessened thereby. Light from below is undesirable. For this reason blinds have been devised to cover the window from below upwards. Frosted glass in front is dazzling and objectionable.

616. **In regard to artificial light** the same remarks hold good. It is also very apt to be deficient in amount, and not evenly and generally distributed—those near to it being dazzled, and those at a distance struggling with too little light. The use of suitable reflectors is to be recommended; and these reflectors may assist ventilation, by being made funnel-shaped and with a tube leading up from the apex of the funnel, as recommended on page 50.

617. **A great increase in the number of cases of myopia** seems to have been caused by the amount of close application of the visual organs in modern times. This is well marked during school life. Some years ago about ten thousand school children were tested by Dr. Cohn, of Breslau, with the following results as regards the number of them who were found to be myopic:—

In the Elementary grade	6.7	per cent.
" Intermediate "	10.3	"
" High School "	19.7	"
" Gymnasium "	26.2	"

618. **Headache, aching of the eyes,** dizziness, and other ailments are caused by undue application to near objects. This is especially the case in children with hypermetropic eyes. Here the difficulty of

accommodating the eyes is much greater; and in these and some of the other cases the strain upon the ciliary muscles is such that they sometimes become weakened, and work has to be suspended. Sometimes, too, a condition of permanent contraction called *spasm of the accommodation* results, impairing distant vision, and causing apparent myopia,—print, etc., requiring to be held close to the eyes.

619. People often mistake this condition for myopia, on account of the person affected not seeing well or distinctly, and bringing the book or other object close to the eyes, in order to get a larger image. This practice causes an increase in the evil result of the mechanical condition.

620. Excessive close application sometimes produces strabismus also. The accommodation and convergence of the eyes are associated movements: when the muscles of accommodation are called into play, those of convergence,—which direct the axes of the eyeballs inwards,—also act instinctively. Often these muscles become permanently contracted, and a convergent squint is produced. This occurs most commonly with those who are naturally hypermetropic. Sometimes, however, the strain on them is so great that they give way under it, and, becoming weakened, produce the opposite condition to that last described—a divergent squint. We have before remarked that when strabismus, or squinting, occurs, one of the eyes is apt to become diseased and lose the power of vision. It should, therefore, be remedied without loss of time, by spectacles, or, if necessary, by operation.

621. Inflammatory affections of the various tissues of the eye are often induced by too continuous application, especially when optical defects exist. This may be seen at times in the inflamed lids and bloodshot eye.

622. The exercises in school should be frequently changed, so as not to keep scholars too long at close application of the eyes—blackboard exercises and object teaching being interspersed with reading, writing and ciphering.

623. Good clear type, not too small, should be employed for school books. The paper should be good, and not so thin as to show the print through on the opposite side, and not too bright and glossy. In reading and writing, the book or paper should be slanting; in

reading, the angle should be about 45°; in writing, this angle will be too great for mechanical convenience. Children should engage in out-door games, and games not requiring near-sight.

624. In no case should the use of spectacles be deferred when they give relief. This remark will apply to presbyopic and far-sighted people, as well as to others. Myopic children, even after the defect has been remedied by spectacles, will often, from habit, still bring objects looked at very close to the eyes. This must not be allowed or the myopia will become worse, on account of the muscular contraction induced by the convergence—the two actions being associated.

625. Reading by a dim light is to be avoided. For this reason we should have plenty of window space, the proportion to floor space recommended varying from foot per foot to one foot in three. Straining the eyes at twilight is a false economy. A flickering light is also to be avoided. Reading in the recumbent posture taxes the eyes unduly, and is otherwise injurious. Reading in a vehicle which has a jerky motion is bad for the eyes, as it causes a vibration of the page, requiring constant change in the position and accommodation of the eyes.

626. In the choice of a calling the condition of the eyes should be taken into consideration. There are some occupations more suitable than others, according as the eyes are myopic or hypermetropic. Then, again, the condition of the eyelids in some persons would render it advisable that they should not engage in occupations in which dust or metallic particles abound. Conditions of general hygiene which affect the eyes are taken up in their proper places.

627. The glare of snow, light-colored soils, water and direct light may be counteracted by spectacles, blue-tinted, or of the color called London smoke. The blue-tinted glass may be also used in connection with artificial light. Blinds, screens, or reflectors of suitable color may also be employed.

628. Quack applications to the eyes should be avoided. Plain water is the proper fluid for bathing the eyes; nothing, however, is to be gained in the case of the healthy eye by forcing it open and bathing it. If, however, there is any discharge, or any foreign substance in the eye, a little tepid water may be allowed to run from a

sponge into it, the lids being held open. If any further medication or other treatment is required, medical advice should be sought.

629. Color-blindness is a defect which, if looked upon in its hygienic aspect, is not any more apt to cause mischief to those affected by it than to others. The colors which blend to form white light are red, green, and violet. By placing these colors on alternate sections of a circular card, and revolving the card rapidly, it will appear white. For the perception of each of these colors there are certain elements in the retina of the normal eye: the absence of one of these sets of elements will produce blindness for the particular color for the perception of which it would be adapted.

630. The results of this defect are serious in connection with the signal lights of railroads and steamboats. It is found to be more common than was formerly supposed. It is also found that some of the tests formerly made are not to be relied upon. The persons experimented upon could distinguish the signals by means of the greater or less brilliancy of the light transmitted, or from the shape of the signal or some other peculiarity. A frame with skeins of various colors intermingled, each having a number attached, which number is concealed from view, is now used for testing, measuring, and indicating the defect. The colors regarding which there is the most serious difficulty are red and green. Statistics show the number of color-blind persons to be 4 per cent. among males, and 0.4 per cent. among females. Although true color-blindness is congenital and incurable, it is desirable that in children not really color-blind the faculty of distinguishing colors should be cultivated and improved, and not allowed to fall into disuse and to become impaired.

CHAPTER XVIII.

THE EAR: ITS STRUCTURE—EFFECTS OF COLD DRAUGHTS—UNDUE EXPOSURE—FOREIGN BODIES IN THE EAR—BOXING THE EARS—IMPORTANCE OF ATTENTION TO DEFECTS OF HEARING.

631. The ear is composed of three parts—the external, middle and internal ear (Fig. 74). The *external ear* consists of an outer projecting part, called the *auricle* or *pinna*, and a canal, called the *external auditory canal.*

632. In the auditory canal (*B*) are found numerous hairs and small glands. The latter secrete a peculiar substance known as the ear-wax. At the inner extremity of the auditory canal there is a thin membrane called the *tympanic membrane*, or drum-head, which divides the external from the middle ear; another partition, partly membranous and partly osseous or bony, separates the middle from the internal ear.

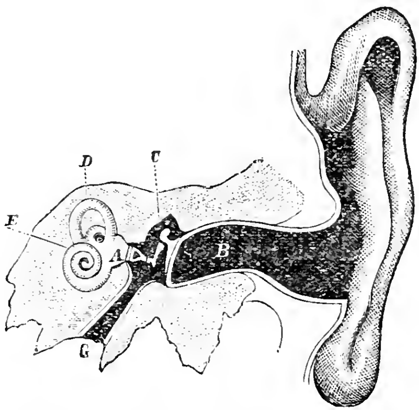


Fig. 74.—The left ear. *A*, vestibule; *B*, auditory canal; *C*, middle ear; *D*, semi-circular canals; *E*, cochlea; *G*, Eustachian tube.

633. The middle ear, or tympanum (*C*), is situated in the bone of the skull called the *temporal bone.* It communicates with the *pharynx* by a long and very small canal (*G*), called the *Eustachian tube.* Through this tube air is admitted from the pharynx into the middle ear. The tympanic membrane is convex on its internal surface. Attached to the drum-head is the handle or long process of a small bone, called the *malleus* or hammer. There are two other bones in the middle ear, the *incus* or

anvil, and the *stapes* or stirrup. These three bones or ossicles are connected together, and form a chain of bones extending from the tympanic membrane to an opening leading into the internal ear, called the *fenestra ovalis*. The foot of the stapes rests on the thin membrane covering the fenestra ovalis.

634. The internal ear, or labyrinth, is composed of the vestibule (*A*), semi-circular canals (*D*), and cochlea (*E*). The *vestibule* is a chamber which communicates with both the semi-circular canals and the cochlea. On its external wall is the fenestra ovalis, closed by the base of the stapes. The *semi-circular canals* are three in number; two are placed vertically and one horizontally and at right angles to the others. The *cochlea* is a spiral-shaped chamber formed like a snail shell. These bony cavities of the internal ear are filled with membranous structures and fluid. In the labyrinth or internal ear as a whole the vibrations of sound are brought into contact with the *auditory nerve.*

635. The tympanic membrane is easily thrown into vibrations by sounds in the air, especially on account of its peculiar funnel shape. Every motion of it is transmitted through the chain of bones and through the membrane of the fenestra ovalis, (to which the stapes is attached), to the fluids within the internal ear.

636. The auditory nerve is distributed to various parts of the vestibule, cochlea and semi-circular canals, where it receives impressions of sounds conveyed to it through the textures of the ear. These impressions are thus conveyed to the brain. The delicate parts within the internal ear are protected from injury by the firm bony structure in which they are encased, and which forms part of the skull. The form and direction of the external auditory canal are well suited to conduct the sonorous vibrations to the tympanic membrane. This membrane is provided with small muscles which regulate its tension, so as to adjust it to the quality and intensity of sounds. The Eustachian tube, by admitting air to the middle ear, preserves the equilibrium of pressure between the external air and that contained within the middle ear.

637. By cultivation and habit the organs of hearing are educated to perceive the direction, quality, intensity, and other characteristics of sound. This is seen in a remarkable manner in the case of conduc-

tors of orchestral performances, who can distinguish the slightest variations from proper time or tune among a large number of musical instruments sounding simultaneously. The well-known acuteness of hearing possessed by blind persons is also an instance of the same fact.

638. The organs of hearing should not be exposed to cold draughts. Permitting children to sit near an open window, where they are exposed to a cold wind blowing upon the head, is wrong. Inflammation of the middle ear frequently results from exposure of this kind—very many of the ear-aches of young children between the ages of four and ten years are due to such inflammation. Frequently these inflammations terminate with no other serious symptom than pain. But all have not such a fortunate ending: the fluid poured out as a product of the first stage of the inflammation may assume the character of pus or matter.

639. This may result in a perforation of the tympanic membrane. In many instances an impairment or loss of hearing, a chronic and generally offensive discharge from the affected ear, or even fatal disease of the adjacent organs, may be produced by inflammation of the middle ear. The latter, whether due to the causes just mentioned or to measles or scarlet fever, should be treated without delay.

640. In cases of catarrh affecting the throat and post-nasal passages, the disease may extend to the Eustachian tube. Constant exposure to overheated and impure air is a very common cause of catarrh—when not operating as an exciting cause, it invariably acts as a powerful predisposing cause. "A cold in the head," as it is commonly called, may be brought about by abrupt transitions from hot to cold, dry to moist, air, or *vice versa;* or again, by first allowing rooms to become overheated and afterwards opening the windows or doors in such a way as to admit injurious draughts. For this reason it is very important that sufficient air space should be allotted to each pupil to allow of a supply of pure air without creating these draughts. Children who are sitting still for hours cannot suffer exposure of this kind without risk. The practice of school children and others of playing out-doors at recess and at other times, in all sorts of weather, without head-covering or other extra clothing, is a prolific source of colds in the head and chest, and should be forbidden by parents and teachers.

641. The swelling of the walls of the Eustachian tube in cold in the head or influenza, may be so great as to obstruct the passage and prevent the entrance of air to the middle ear. The contained air in the latter then undergoes absorption and a vacuum is caused. As a result of all this, the tympanic membrane assumes an unnatural position, and there is dulness of hearing, with more or less pain or discomfort. Sometimes chronic disease, catarrh of the middle ear, and permanent loss of hearing result from one or more attacks of this kind.

642. Frequently this affection is allowed to go on unchecked until not only partial deafness is experienced, but defective pronunciation of certain words results. In well-marked cases, owing to more or less thickening or redundancy of the tissues where the throat and nose join, breathing takes place through the mouth, instead of through the nose, the latter being obstructed, and there is difficulty in raising the voice so as to sing high notes. Meyer has called attention to this condition, which may be recognized by its causing what he terms "dead" pronunciation. He examined two thousand children in the public schools of Copenhagen, and found the above described symptoms well marked in one per cent. In England he found nearly two per cent. thus affected. The relation which catarrhal affections, with all their ultimate consequences, bear to the organs of hearing is a matter of great importance. Deaf-muteism is not nearly so often congenital as was once supposed, but is in many cases an acquired condition, the final result of catarrh of the middle ear during infancy or early life, more or less amenable to treatment.

643. Frequently there is an excessive secretion of wax in the external auditory canal. In this case efforts to extract it may result in packing it more tightly against the tympanic membrane. Temporary deafness, or even inflammation, may be caused in this way. Great care should be exercised in introducing any instrument into the external ear in order to remove the wax. A pencil, sharp-pointed pen-holder, match, or anything else not adapted for the purpose should never be used. Syringing with warm water is the only safe remedy for people themselves to employ in order to remove wax from the ears.

644. Foreign bodies, such as paper, small pieces of pencil, beads,

peas, etc., are often introduced into the ears, especially by children between the ages of four and eleven, and may cause serious consequences. Rough and awkward attempts to extract such substances from the ear should not be made. If an insect enters the ear, a good plan is for the person to lie down on the opposite side and have a little warm water or oil poured into the ear, keeping that ear uppermost till the insect escapes or ceases to move. If it does not escape, an attempt may be made after a little time to remove it by syringing.

645. Striking the ears with the open hand, commonly known as "boxing the ears," is a practice that should not be indulged in. There is a possibility of injuring the organs of hearing by a blow on the side of the head inflicted in this manner.

646. Teachers should carefully observe conditions of hearing in pupils. Any causes operating to injure the organs of hearing should be at once detected, and means should be adopted for their abatement or removal. When no attention is paid to the matter, the hearing of pupils may be much impaired before teachers or parents are aware of it. The distance at which the ticking of a watch or a whisper in ordinary tones may be heard by each ear separately, furnishes the simplest and best test of the power of hearing. The normal ear can distinguish ordinary whispered tones at a distance of twenty feet, and ordinary conversational tones at sixty feet. The answers, especially of a young child, are apt to be biassed by reading the motions of the lips. In testing the hearing power, care should be taken to see that the eye does not thus assist the ear. It is desirable for the teacher to note any defects, in order that he may avoid blaming wrongfully any pupil for inattention, when in reality the inattention results from partial deafness. Teachers may find, for instance, that a child is inattentive merely because partial deafness prevents him from following closely an explanation of a lesson. Losing part of a logical exposition of a difficult problem may detract from the interest the pupil might otherwise have taken in it. In such a case punishment or rebuke would be unmerited and very unjust. Parents should be duly informed of any such defects, in order that the child may be placed under treatment.

647. A pupil may acquire a reputation for dulness when his apparent want of perception is entirely attributable to partial deafness.

In this way he may not only be deprived of the advantages of school exercises, but may also lose that self-confidence and self-respect which are necessary to stimulate him to continued exertion. A teacher who neglects to discover the true cause of slowness of apprehension on the part of such a pupil, and discourages him by uncomplimentary remarks in the presence of his classmates, is manifestly committing a most serious mistake. A pupil who, through partial deafness, is unable to enjoy the advantages of school life, and who meets with ill-timed rebukes, very soon entertains a dislike for his school. In this way many different kinds of evils result which are all traceable to one cause, and could be remedied if the true cause were discovered.

CHAPTER XIX.

SCHOOL FURNITURE: SCRAPERS AND MATS—LAVATORIES—HAT-HOOKS—SEATS AND DESKS—BLINDS—BLACKBOARDS—THERMOMETERS—DRINKING UTENSILS.

648. Scrapers and mats should be provided and placed in front of the school-house door, in order that neither dust nor mud may be carried into the school-room. The mats should be coarse and rough, so as to remove all mud from the boots. The space in front of the door should be covered with plank or stones, and kept clean. Every precaution should be adopted to prevent the accumulation of dust on the floors: otherwise it will be raised by the movements of the children in the room, and enter the respiratory passages with the air; thus bronchial irritation and various lung affections are produced or aggravated.

649. One or more wash-basins should be provided in rooms set apart, one for each division, so that children after play, and before entering the school-room, may wash and prepare themselves to appear clean and neat during school hours. Towels, a looking-glass, and other necessary articles should be provided and kept in proper order. Children having any contagious disease, or other communicable affection, should not be allowed to transmit such affection by the careless use of towels. Each of such pupils should provide a towel for himself.

650. Clothes and hat-hooks should be numbered, so that each pupil may retain his own hook. The cloak-room should in no case be the same as the school-room, but should be apart from it, and should be so arranged that the children can pass freely through it or around it without incommoding each other.

651. The position of a pupil and the suitability of his desk are very important considerations. Short-sightedness, spinal deformities, compression and narrowing of the chest, enfeebled digestion and interference with the free and perfect development of the respiratory

organs may result from improper seating of children. Stooping forward over a low desk, or a desk projecting too far over the edge of the seat, tends to produce congestion of the head and short-sightedness. If the desk is too high, the right shoulder will be raised above the left, the body will be bent to one side, and spinal curvature caused. The desk should not be too far away from the seat, causing the pupil to lean forward and assume an unnatural position while writing. In young children the bones and ligaments are soft and yielding; by constant stooping or bending to one side the spinal column assumes an unnatural curve (Fig. 75). If such a deformity is allowed to exist for years, the malposition becomes permanent. Children who are predisposed to weakness and deformities claim our special attention in this respect. The contrast between Figs. 76 and 77 illustrates the desirability of careful attention to this matter as well as to the necessity of warning children against the habit of stooping. If the pupil manifests discomfort and restlessness, attention should be directed to his seat and desk, in order to find whether he is properly seated: (1) His feet should rest comfortably on the floor. (2) His back should be properly supported, and his thighs placed at right angles to his body. (3) There should be a suitable distance between his seat and desk. Dr. Liebreich claims that the edge of the desk should be in a perpendicular line with the edge of the seat. This is found practically to be correct. (4) The height of the desk should be such that the lower or front edge shall touch a point a little below the pit of the stomach; (5) and that when the pupil is writing, his arm from the shoulder to the elbow shall rest by the side of his body, and be at right angles to his fore-arm resting on the desk. (6) The back of the seat should project forward to support the loins, and it

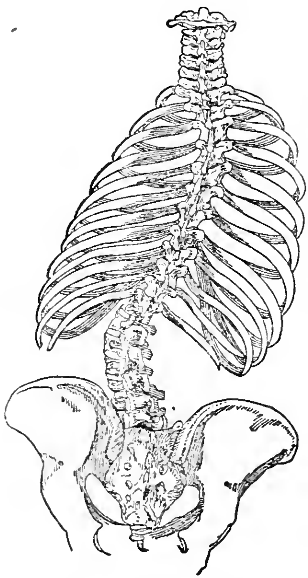


Fig. 75.—Spinal curvature.

should be very slightly concave, to support the shoulder blades comfortably. The seat may be adapted to the curve of the thigh.

652. Seats and desks may be so constructed as to be adjusted by the teacher to suit the respective heights of the pupils. We find in a French work on School Hygiene,* two models of seats and desks, which might very well be combined, so as to give us those represented

Fig. 76.—Spinal deformity.

Fig. 77.—Natural position of the body.

in Fig. 78. The seat, *M*, and desk, *B E*, are supported each of them on a sliding pin, *F*, which works in a socket, *G*. The seat and desk may thus be raised or lowered to any required height, and may be fixed at that height by the set screw, *H;* or the foot-rest, *I*, may be moved, the desk being left stationary. This latter plan keeps the feet off the floor, an advantage in cold weather and in draughty rooms. The top of the desk is attached to the rest, *C*, which is

* Hygiène Scolaire, Influence de l'École sur la Santé des Enfants, par A. Riant. Paris: Hachette et Cie., 1882.

hinged at *D;* in this way it is made to slide forward to *A*, when the pupil requires to stand up, and it does not necessitate his moving out into the aisle; when he is seated it can be easily drawn towards him. The backs of the seats may have cross-pieces at *O*, or be otherwise

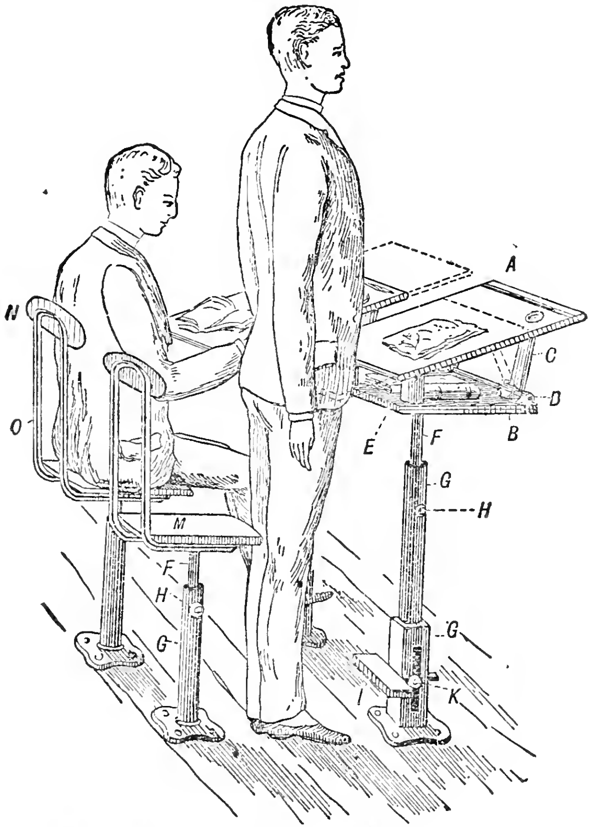


Fig. 78.—Adjustable seat and desk, the latter with sliding top.

altered from the pattern given in the figure, so as to render them more suitable for supporting the shoulders and spinal column. The tightening bolts should be secured into position by a wrench, which should be in the possession of the teacher or caretaker, so that the pupils may not meddle with them.

653. The pupils are measured every six months in France and some other European countries, and seats and desks of suitable proportions are assigned to them. Dr. Guillaume states that the seats at the École Première were altered in this way with excellent results. Rules have been laid down, and tables prepared, giving measurements to guide teachers in regulating seats for children. A test of these tables shows that in some instances they are not strictly correct, nor are they suitable for practical application, owing to varied proportionate developments of different pupils. Movable seats and desks should in all cases be provided.

654. Continuance too long in one position causes fatigue of a certain set of muscles, and these become relaxed. Thus there may be an unnatural and unhealthy position assumed, which may become habitual. When the muscles which should support the spinal column become tired they relax, the burden of supporting the superincumbent weight of the head and shoulders then falls upon the ligaments, which are not able for the work imposed upon them, and the conditions described in Sec. 651 are gradually produced. To prevent these results pupils must be advised and encouraged to avoid injurious positions and postures, and the relaxations and exercises recommended in the next succeeding chapter should be carried out.

655. Blinds or curtains should be provided for all the windows. These should be so arranged as to enable the teacher to regulate the supply of light properly, as circumstances require. (See Sec. 615.)

656. Blackboards of a dark green color, and having a dead surface which does not reflect a glare of light, are to be preferred. There are obvious advantages in having blackboards which may be moved about and set in any required position.

657. Drinking vessels should be provided and attended to, as described in Secs. 572 and 581. There should be a hook at a convenient place for holding the cup when not in use. A supply of water to be used in case of fire is necessary, especially in buildings of more than one storey.

658. A thermometer should be kept in each room, and the temperature accurately noted. (See Secs. 156 and 158.)

659. Care of furniture is regulated by instructions of the Education Department. Rooms should be swept at night, and dusted in the

morning. Desks and seats should be carefully dusted every day. They should be washed frequently, in order to remove all dirt adhering to the wood.

660. School-rooms should be made cheerful and attractive. Flowers, pictures of eminent men or places prominent in history, are useful and attractive in a school-room. The cultivation of flowers, trees and shrubbery on the grounds tends to educate and refine the tastes of pupils, who should be taught to protect and admire all that contributes to the beauty and comfort of the school-room and surrounding grounds.

CHAPTER XX.

PHYSICAL EXERCISE: VOLUNTARY AND INVOLUNTARY MUSCLES—STRUCTURE OF MUSCLE—WALKING—LEAPING—RUNNING—ROWING—FENCING—HAND-BALL—RIDING—IRRATIONAL ATHLETICS INJURIOUS TO THE HEART, LUNGS AND LIMBS—GYMNASTICS AND CALISTHENICS—RECESSES—SINGING—KINDERGARTEN EXERCISES.

661. Exercise is a subject of vital importance, especially to those who follow sedentary pursuits. The remarks in this chapter are more particularly addressed to students, who, in order to obtain mental improvement, often forget to pay attention to the wants of the body. As usually employed, the term exercise refers to the action of the voluntary muscles. Muscles are classed by physiologists under two heads, the voluntary and involuntary.

662. Voluntary muscles are those which execute movements under the influence of the will, as the muscles of the head, limbs, trunk, etc. Thus, in Fig. 81 we see that the position of the right arm is represented as produced by the action of the will on certain voluntary muscles, viz., the biceps (*b*), the two pectoral muscles (*pp*), and the deltoid (*d*). Voluntary muscles antagonize each other in almost all parts of the body. The extremities have flexors and extensors, pronators and supinators, adductors and abductors, rotators inwards and rotators outwards. When the muscles of one side of the face are paralyzed, the muscles of the opposite side draw the features towards their side. When one-half of the tongue is paralyzed, the point of it is seen, when protruded, to be forced towards the paralyzed side by the action of the muscles of the opposite side. Hence it appears that these muscles are, when in their healthy state, always in a condition of slight contraction, and that the state of inaction of the different parts of our bodies does not indicate an absolutely relaxed condition of the muscles, but rather that the different groups of

muscles antagonize and balance each other, and that when the position of a part is changed from the medium state of apparent rest, one or more of the muscles, already in a state of antagonistic action, are merely thrown into more powerful contraction.

663. By muscular contraction is understood the exertion of the power possessed by the muscles of shortening themselves, or of contracting, to produce motion.

664. Involuntary muscles, as the heart, fleshy fibres of the intestines, etc., do not require an effort of the will for the exercise of their functions, and their continued action does not cause any sensation of uneasiness. The movements of these muscles are performed unconsciously, and yet perfectly, without experience or education of the mind, through the action of certain special stimuli.

665. Muscular fibre (Fig. 79) is a name given to the filaments, which by their union form the muscles. This fibre is flat, soft, downy, linear, and somewhat elastic. It is itself composed of a considerable number of fibrils, similar to each other, and subdividing almost *ad infinitum.* The ultimate fibrils seem to be tubular. There are two forms of muscular tissue, the striped and the unstriped. In the former the fibres have little transverse markings or *striæ;* in the latter they are plain. Muscles composed of striped fibres are, with a few exceptions, of the voluntary class, and minister to voluntary motion and the functions of animal life. The unstriped are, perhaps, always involuntary, and minister to the functions of vegetative life or simple existence. The color of the muscular fibres is red in man and most of the higher animals. The muscular fibre shown in Fig. 79 is of the striped variety.

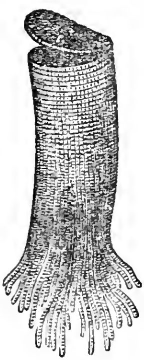


Fig. 79.
Muscular fibre.

666. A voluntary muscle consists of a greater or less number of these fibrils united in bundles, approximated to each other, and forming a distinct mass of very variable size and shape, the extremities of which are attached to bones by means of tendons. In this are included cellular tissue, vessels and nerves. The cellular tissue serves to unite together the fibres, and it also forms to each muscle an external envelope, which unites it to the neighboring parts and

admits of its motion. Arteries proceed to the muscles from neighboring trunks, and are always large in proportion to the bulk of the muscle. Nerves follow the same course in the muscles as the arteries. Nerves proceed from the brain and penetrate to the fleshy tissue with the vessels, with which they are closely united. After they have entered the muscles they divide and subdivide until they are lost sight of. Although we do not know the exact changes going on in the muscles, there is no doubt that with constant, regular exercise a muscle enlarges, becomes thicker and heavier, contains more solid matter, and has, in fact, gained in nitrogen. This process may be slow, but it is certain, and nitrogen must either be supplied by increased food or be taken from other parts.

667. Rational athletics tend not only to improve the health, but, if systematically carried out, along with a regulated diet and increased action of the eliminating organs, they produce the highest type of healthy and vigorous living. We shall now proceed to indicate a few of those exercises which may be included under this term. They may be either active or passive.

668. Walking on a level surface is the gentlest form of active exercise; the muscles of the extremities, trunk, abdomen and neck are thrown into moderate action, which does not produce fatigue, if the pace is not too rapid and if no weight is carried. In ascending or descending a hill, the motion is more violent, and the shaking of the body is greater, so that fatigue is more rapidly induced. The amount of walking required by different persons varies greatly. Dr. Parkes recommended for an adult a walk of nine miles a day, which would be equivalent to 150 tons lifted one foot. But as there is much exertion taken in the ordinary business of life, this amount may be in many cases reduced. It is not possible to lay down rules for all cases, but a walk of four to six miles a day seems to agree with the constitution of the majority of men; they eat and sleep better, and all the functions of their systems are performed with greater satisfaction when that amount of exercise is taken daily.

669. Leaping or jumping jars the body violently. It is only suited to the period of youth, when the cartilages are soft, and can, by their elasticity, moderate the violence of the shaking. In adults and old people, in whom the cartilages have become indurated and have lost,

to a certain extent, their elasticity, it is highly improper, and is frequently followed by serious consequences.

670. In running there is a succession of leaps, which quickly produces fatigue and excites the lungs and heart violently. It is not suited to the later periods of life. Games such as football, lacrosse, baseball and cricket come under the head of running, and the suitability of any of them to certain periods of life is to be measured by the same standard which has been applied to it. When properly played, they are useful forms of exercise for healthy boys or young men.

671. Rowing is an excellent athletic exercise, and one which, fortunately, can be very generally indulged in by the people of this country. It is suitable to all periods of life, from childhood to old age. It is of great value to young men, particularly those of sedentary habits, since it tends to develop the muscles of the chest, and the exertion, without being necessarily severe, causes a healthful action in nearly all the muscles of the body and extremities.

672. Fencing also develops all the muscles of the trunk and of the upper and lower extremities. It also necessitates great activity of the mind and quickness of vision, in order to resist successfully an opponent's attack. The foil should be used with the left hand as well as the right, so as to develop both sides of the body equally.

673. Fives, or handball, is a very useful form of active exercise, quite free from objection on the score of roughness, and calculated to call into activity all the muscles of the trunk and both upper and lower extremities. It also calls for considerable quickness of vision, and is altogether, when well played, a very attractive game for both the players and the spectators. In some large schools it forms the principal source of amusement. This game is peculiarly adapted to the wants of those who live in towns. It only requires three walls and a limited space, needs no grass, and affords most bracing and exhilarating exercise in a short space of time. The full-sized court in which it is played consists of a cemented, paved or neatly boarded floor, about 30 feet long by 16 feet wide, a back wall 16 feet square, and two side walls beginning at 16 feet high at the one end and gradually sinking to about 5 feet at the other. A small hard ball is used to play with, and the object is to strike the ball with the palm

of the hand against the wall, so that it bounds back on the floor of the court for the opponents to strike in a similar way. By using the side walls the ball is made to pass through many angles before it reaches the floor, and, in consequence, its course is more difficult to follow. Either hand is used equally, and thus this exercise has the great advantage of being uniform, and bringing both sides of the trunk and chest into action. In this country, owing to the cheapness of timber, a fives-court could be put up at but little expense.

674. Horse-back exercise is of all the forms of passive exercise the most useful; and it is not a purely passive exercise, as a considerable amount of muscular exertion is necessary to retain one's seat when the motion is rapid.

675. Riding in a carriage and sailing are forms of passive exercise which are conducive to health, on account of the change of air and the constant succession of novelties. Unfortunately, sailing is, in some cases, attended by the disagreeable sensations included under the name of sea-sickness; but, in spite of this drawback, it is very beneficial for invalids, and is often the most valuable remedial agent that can be employed during convalescence.

676. Irrational athletics include all those exercises which cause disease or injury to the body or any portion of it. As the true aim of all athletic pursuits is to increase muscular power, and thereby improve the general condition of the body, only those forms of exercise should be practised which accomplish the desired object with the least possible injury to the body. As an example of athletic sports unwise from a sanitary point of view, take boat-racing. A perfectly sound man may train for boat-races, and may win in a good many, without injury, but the strain upon his heart and lungs during the race is considerable. Not that the handling of the oar is heavy work, but the velocity of the repeated acts which constitute rowing at racing speed has to be considered in this estimate. For instance, in the Oxford boat-races, rowing at racing speed (= 1 mile in 7 minutes), in an Oxford eight-oar, or 18.56 foot-tons in 7 minutes, is not apparently very hard work, but it is very severe for the time, as its effect is great on the circulatory system.

677. Heart disease may sometimes result from over-exertion in athletic sports, though we think the cases are few in which it

can be traced to physical exercises alone. Instances are, however, on record showing that severe labor, as in the case of soldiers who have done heavy marching during a campaign, has caused enlargement and dilatation of the heart.—(Flint.) The same author also states that "rupture of the valves or tendinous cords of the heart sometimes results from the violence of the heart's action, without any previous structural change." Hence it is reasonable to infer that continued muscular strain, involving great speed, either in walking, rowing, or running, tends to produce a simple enlargement of the heart muscle, and, in other cases, it causes damage to the valves and tendinous cords of the heart, which is subsequently followed by enlargement and dilatation. Figure 80 exhibits a cross section of the heart, with the valves which guard its orifices. In a healthy heart, such as is here shown, these valves open, to permit the blood to flow in one direction, and close with great accuracy, to prevent it from returning. Injury to the valves or to the tendinous cords which hold the mitral and tricuspid valves in position, prevents the valves from closing with accuracy, and interferes with the proper onward current of the blood, by permitting some of it to flow backwards.

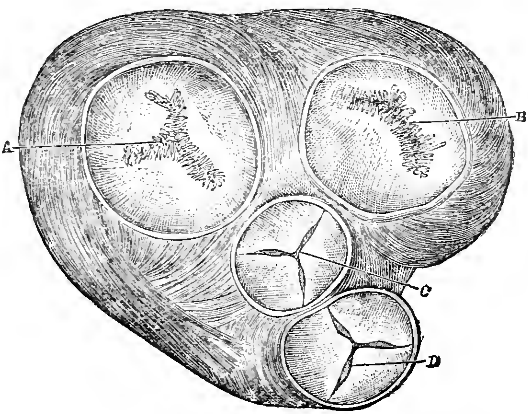


Fig. 80.—Cross section of the heart, showing: *A*, tricuspid valve; *B*, mitral valve; *C*, semilunar valves of the pulmonary artery; *D*, semilunar valves of the aorta.

678. Emphysema, or excessive and permanent dilatation of the air-cells, may be produced by prolonged forcible efforts of expiration, as in long-continued exertion at lifting or pulling, the elasticity of the lungs being diminished. This condition is characterized by breathlessness on exertion.

679. Fracture of the collar-bone, or of the bones of the extremities,

occurs occasionally during football matches. Lacrosse matches appear to be fertile in contributions to surgery; but these, and other athletic games, can be skilfully played without any of the contestants sustaining injury, if fair play is insisted on. Looking at the subject from another standpoint, it is consoling to those who are fond of regular athletic sports, to learn from the head-master of an English public school, with an attendance of five hundred scholars, that "quite as many sprains, bruises and cuts arise from skylarking as from all the organized games put together." The head-master of another English school, with nearly as many scholars as the preceding one, says: "The football accidents, though apparently numerous, are really trifling. On an average, 500 boys play two games a week for ten weeks, giving a total of 10,000 games of individuals; the number of broken collar-bones and arms may amount to two or three per annum. A broken leg or a serious brain concussion may occur once in ten years, *i.e.*, once in 100,000 games. Accidents to knees are most troublesome. There have been no accidents, except one, which I would consider really serious. This was a blow on the head, which was neglected, and it brought on serious inflammation, and required more than a year's rest." These opinions, coming from such important sources, are very valuable.

680. Gymnastics, as a general rule, should be undertaken systematically, in a regular gymnasium, under an instructor's eye. If boys are turned loose into a gymnasium, they will probably do themselves more harm than good; the exercises should be designed for the requirements of each, and should be steadily increased. They may be carried on more appropriately in winter than in summer, as the severity of our climate and the amount of snow on the ground occasionally prevent boys from engaging in the games to which we have already alluded. Certain kinds of gymnastic exercises are calculated to do harm to growing lads, more particularly exercises which cause them to hang head downwards for a long time. In using the climbing rope or pole, boys should not be allowed to support the weight of the body with the legs. Skating is a favorite winter amusement in Canada, and if not indulged in so as to cause overheating, is one of the finest athletic exercises. Coasting and tobogganing are indulged in by Canadian boys during the cold weather with great zest. If the use

of snow-shoes were more general, brisk walking exercise could be indulged in, even when the snow lies deep upon the ground.

681. Calisthenic exercises and work with the light Indian clubs and dumb-bells appear to be particularly suitable to girls during the winter-season. Walking should never be neglected, and whenever the season will permit, romping games, such as "I spy," etc., will be useful; also skipping ropes and dancing for younger girls. For older girls, lawn tennis and similar games in summer, with plenty of brisk walking and climbing.

682. Rooms used for gymnastic and calisthenic exercises should be provided with a very large supply of fresh air: and, if it is possible, these exercises should be carried on in the open air. In fine weather there will be no difficulty in doing this, and in wet or cold weather they can be carried on with great satisfaction under a long shed, boarded up on all sides, and properly heated and ventilated. These sheds should not have boarded floors, but a ground of loose sand or sawdust, which can be raked up from time to time to render it soft. This plan is followed in erecting covered gymnasiums in Switzerland, where considerable attention has been paid to the subject.

683. Alternation of physical with mental exercise is necessary to the well-being of the system, and enables it to undertake mental labor with greater satisfaction and better results. A change from one to the other is desirable for the following reasons:—(1) Continued application to study is injurious to the eyes, and soon causes short-sightedness, even in the young. Physical exercise proves of service here by interrupting the application of the eyes to near objects, and exercising them in calculating distances for jumping, vaulting, and particularly in sword exercises, where the eye observes not only the movements of the foil or single-stick, but reads in the eyes of the opponent his intended thrusts or cuts. (2) Physical exercise banishes inattention, which is a clog to all moral and intellectual improvement. Menier says, "that the gymnast shows his perfection when he can with the greatest coolness use every power of the body for some definitely given object, and in making use of every advantage, execute apparent impossibilities through gradually won dexterity. As long as he does not give attention to what he is doing he is in danger." (3) It also conduces to activity and the acquisition of purpose and object in

study, which, in conjunction with attention and a cultivated memory, produce surprising results. (4) It preserves the strength of the body, which is necessary for the proper acquisition and retention of knowledge; for, as Hippocrates says, "the strength of the mind increases with that of the body. When the body is diseased the thoughts are distracted." (5) Alternation is beneficial, because it rests the brain. Close and long-continued thinking produces in many a feeling of exhaustion and slight oppression in the head. This arises from the fact that the brain, which is the organ of thought, has been exercised, and requires rest. Now, experience proves that the necessary rest is best taken, particularly during the active season of youth, by exercising the voluntary muscles; and though those exercises are of themselves conducive to hilarity, their refreshing effect on a wearied brain is much higher if they be taken in company with other persons of a congenial turn of mind. But it must also be understood that physical exercise may be carried to excess, and produce the opposite effect. Intense, long-continued muscular labor is incompatible with intellectual advancement. The laborer is too wearied to study; all his nervous force is expended on his muscles, and there is nothing left to stimulate his intellect.

684. Recesses are of special value, inasmuch as they permit of complete mental relaxation for a short time, during which the scholar has an opportunity of acquiring the much needed bodily exercise. In imperfectly ventilated school buildings, which appear to be very numerous, an opportunity is afforded during recess for more completely changing the air.

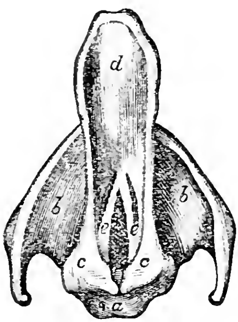


Fig. 82.—The larynx, as seen from above: *a*, *b*, *c*, cartilages of the larynx; *d*, epiglottis; *e*, *e*, vocal cords.

685. Singing also forms a pleasing interlude between various mental exercises. In addition to its charming effect on the mind, the regulated use of the voice in singing acts beneficially in developing and strengthening the muscles of the chest, and increasing the breathing power of the lungs, thus preventing the inroads of pulmonary disease. It also lays the foundation of a correct modulation of the voice, which subsequently proves very useful when the children are

learning to read aloud. A reference to diagram 82 will show how the mechanism of the voice is produced. The vocal cords (*e e*) are not really cords, but merely elastic membranes, projecting from the sides of the larynx, across the opening, which is called the glottis. When not in use they spread apart and leave a V-shaped orifice, through which the air passes to and from the lungs. If the cords are tightened, the edges approach sometimes within $\frac{1}{100}$ of an inch of each other, and being thrown into vibration, cause corresponding vibrations in the current of air. Thus sound is produced in the same manner as by the vibrations of the strings of a violin, only in this case the strings are scarcely an inch long. The higher tones of the voice are produced when the cords are short, tight, and nearly in contact, the lower by the opposite conditions. Loudness is regulated by the quantity of air and the force of expulsion.

686. The kindergarten, or children's garden, is, as its name would imply, of German origin. It is a system of education intended specially for children from three to six years of age. The fundamental idea is, that in the case of a young child, education of the mind should be combined with activity of the body. The children are not, therefore, confined in constrained attitudes, but are allowed to group themselves about the instructor, and whatever they are taught is reduced to practice. Thus, in lessons on form, so as to educate the eye, they are told that a certain object is square, *i.e.*, has four sides and four equal angles, and they are taught to fold a piece of paper so as to represent a square. Other shapes are represented in a similar way. In their singing exercises they are also trained in proper modes of breathing, expanding the chest and enunciating, and the sense of hearing is carefully educated, just as they are trained in walking, looking and handling. A considerable amount of physical exercise can also be introduced, for the purpose of exciting muscles which are in danger of being neglected. Thus a child may be told by the teacher that he is a bird, and may be taught to imitate with his arms the movements of a flying bird, or he may be encouraged to exercise the muscles of the leg, hip and thigh, in balancing himself, by leading him to hop about like a bird in search of food. If the exercises are judiciously varied, the children may be trained to go through them, not only without weariness, but with positive pleasure.

CHAPTER XXI.

MENTAL EXERCISE: MUTUAL DEPENDENCE OF MIND AND BODY—OVER-PRESSURE—COMPETITION—HURRY AND WORRY—THEIR RESULTS—OPINIONS OF EMINENT AUTHORITIES—SCHOOL AGE—AGE OF PUBERTY—SENSATIONAL LITERATURE—HALF-TIME SYSTEM—VARIATION OF MENTAL EXERCISES—MENTAL REST—SLEEP—VITAL STATISTICS—BRAIN DISEASES NOT PROPORTIONATELY DIMINISHED—INCREASE OF SUICIDE.

687. **Education may be defined** as the art of developing and cultivating the various physical, intellectual and moral faculties, and care must be taken that none of these be injured by the means taken to develop the others. The peculiarities of mind and body of children should be noted, so that during their growth and development weak points may be strengthened and strong points wisely directed. A good foundation should be laid by endeavoring to promote a sound mind in a sound body. Nature resents a forcing-house treatment of any faculty or power too early in life by dwarfing others. Exercise and play are nature's best aids to proper development.

688. **So close is the mutual dependence of the physical, mental and moral** faculties, that an improvement or deterioration in any one, is certain to be ultimately attended by an improvement or deterioration of the other two. If, from indifferent sanitary arrangements in the school-house, or from mental overstrain, the physical powers decline, the mental and moral forces must soon be weakened.

689. **The process of growth and development of the brain** from birth to maturity may be likened to the gradual creation of a telegraphic or telephonic system; "but," remarks Dr. Clouston, "all the hundred thousand telegraph wires and batteries and telephones in all London are a simple and intelligible system compared to the nervous apparatus of cells and fibres in one human brain. The number of

groups and associations of groups that can be made out of 1,200,000,000 cells, no mathematician could calculate, and no one can imagine."

690. Over-pressure in study produces an irritated condition of the brain and its membranes which occasionally runs into tubercular meningitis; nervous twitchings and choreic movements of one kind or another are also occasional consequences to children from overwork at school, and long lessons to be mastered at home. Unnatural forcing before the brain structure is developed is an objectionable and unsafe proceeding, and may entirely defeat the objects of education. Bad constitutions, with the seeds of disease in them, unfit to stand the strain of life, are often the result of improper or imperfect growth and development.

691. The present system of rank and reward, based on success in reaching a certain standard, or in out-stripping others, is a great temptation to over-pressure, and should, therefore, be guarded against, especially in the cases of scrofulous or nervous children. Every mental effort is attended by brain wear; the greater and more prolonged the effort the greater the wear; unless sufficient time is allowed for repair, exhaustion ensues, and the brain is rendered less capable of renewed effort.

692. The habit of attention, is weakened by over-taxing the mind; and without a proper alternation of rest and work, instead of success in expanding, disciplining and improving the intellect, there will result only intellectual weakness, without the power of concentrated thought.

693. In this age of increasing nervousness or susceptibility to impressions, the effects of overtension or overstrain of the nervous system are particularly to be dreaded. They are insidious, often disguised for a time, attributed to other than the real causes, and frequently lead to a complete breakdown in the student's career, or to a necessity for a long period of repose to refit him for further work. Professor Humphrey, at the Glasgow Congress of Sanitarians held last year, remarked: "Many who have succeeded in reaching the examination goal had better never have sought it, never regaining the mental elasticity which heavy pressure has weakened, and disappointing the hopes which early distinction had raised." After referring to dangers to be avoided in the education of women, he

adds, "it is satisfactory to mark that the movement has been attended by a corresponding enlargement of the range and amount of bodily exercise. The gymnasium and lawn-tennis ground are the antidotes, and, therefore, the correlatives, to the study, and we may have good hope that increased and well-balanced exercise of body and mind will lead to a better development and greater strength of both."

694. "Give our girls fair opportunities for physical development at school," says a French author, "and they will be able in after life, with reasonable care, to answer the demands made upon them. Impair their muscular vigor by confining their growing frames in the fatal chains of fashion, and you increase debility, and even deformity in the race to come. If we want our girls to be made straight, let them be made strong."

695. One of the principal effects of continued tension of the brain is to weaken all the organs more or less dependent on it, by depriving them of a part of the nervous influence necessary to their action. The organ most influenced by this privation is the stomach, and, as a rule, men who think most digest the worst. The sedentary life of profound thinkers has, however, a good deal to do with the delicacy of this organ.

696. "Success in the world depends on energy rather than on information," says Herbert Spenser, in his work on Education, "and a policy which, in cramming with information, undermines energy, is self-defeating." Mr. Pridgen Teale, in a recent presidential address at Huddersfield on this bane of modern education, wound up with the following remarks: "Yet let it not be supposed that I am depreciating true education, or advocating idleness, or undervaluing hard work. Industry and hard work I value and sympathize with, both in educational and active life. Nay, more, it is my belief that hard work and long hours of work do not of themselves constitute overpressure in education or overwork in life."

697. "It is the work which is done under perpetual worry and anxiety, and under compulsion of want of time, that tries the health of young and old. It is because we are importing into our modern education hurry, worry and anxiety, selfishness, competition, and feverish desire for success, prize-winning, place-winning and mark-

winning, all tending year by year to grow in intensity and become more powerful agents, that we have reason to fear it will result in injury to health, degradation of intellect, and to the departure from a true ideal of education."

693. By the hurry and rapidity, and number of subjects required to be learned in this railroad era, great injury is undoubtedly done to the mind. In the case of children approaching the age of puberty, there is special occasion for relaxation, particularly in the case of girls. Dr. Lincoln, writing on this subject, remarks: "The growth of girls for two or three years from the ages of eleven or twelve onward is very rapid, in fact, they then surpass boys of their own age, both in height and weight. . . . . This rapid growth, and . . . . the moral development which should go with it, form, during those years, the most important functions of their existence." At this period children should be carefully watched, and their work diminished.

699. The age at which a child should go to school depends much upon the physical strength and temperament. For the kindergarten, from five to six years of age, and for the commencement of a systematic course of education, probably from seven to eight years of age, may be taken as an approximate standard.

700. At fifteen a new epoch commences. The passions are awakened, and the care of parents and teachers should now redouble. The former should exercise oversight of the character of the books read at home, prohibiting a great deal of the sensational literature of the day. The same remark applies to some quasi-scientific works on certain physiological subjects, the perusal of which is apt to do harm by engendering prurient ideas.

701. To keep children for two or three hours at a time in the often ill-ventilated school-room is open to grave objection. In England, most beneficial effects have resulted from what is termed the "half-time system," viz., three hours daily at school, and out-door employment on farms or in workshops for the rest of the working hours; and it has generally been found that children thus employed make as good progress in study as those who attend school for six hours a day.

702. The amount of work involved in home lessons should be carefully considered by the teacher, even though at first it may give

him some trouble, and require some practical testing, to arrive at a just estimate of the time which they will occupy. The health of children may be injured by application unduly protracted in the evening, when mind and body are weary and should be resting. On the studious child injury is inflicted, though cheerfully borne; in those who are not so quick, besides the injury done to their health, a dislike to study is engendered.

703. Mental rest may be obtained by changes of occupation. Change from one subject to another relieves the mental tension that would be experienced by long and uninterrupted application to one subject. A brief intermission may be given at the end of each hour, during which gymnastics and other suitable exercises may be practised by the scholars under the superintendence of the teachers. The physical exercises tend to promote the health of the pupils, and also greatly conduce to their comfort. Singing by the pupils in concert is an exhilarating and profitable exercise during school hours.

704. Sleep in abundance is most necessary during the process of development. Up to four years of age the minimum amount of sleep should be twelve hours a day, eleven hours from that to seven years, ten and a half hours from seven to ten, ten hours from that age to fifteen, and nine hours up to twenty years of age.

705. We are told by persons in authority, that the death-rate of children is diminishing. In evidence of this, Sir Lyon Playfair, in a speech delivered in the House of Commons in July, 1883, quotes the tables published by the Statistical Society. Two periods are compared together, 1838 to 1854 and 1876 to 1880. In the latter period, among children from five to ten years of age, there had been a diminution of mortality of nearly thirty-five per cent., of which but six per cent. could be accounted for as the effect of improvement in sanitary surroundings.

706. But in diseases of the brain the percentage has not been reduced. Some interesting facts in this connection may be gleaned from the last Report (1885) of the Registrar-General of England, and the observations of Dr. Crichton Brown, the Superintendent of the Edinburgh Asylum for the Insane. The increase of deaths from hydrocephalus, or water on the brain (which has taken place of late years), has not been among infants, but amongst persons over five

years of age. In deaths from consumption and other wasting diseases, overwork has also been a leading feature in the failure of health. In Germany, Dr. Freichler has called the attention of physicians to the great increase, among boys and girls, of habitual headaches, which he attributes to the exhaustive effort of excessive and ill-directed brain work in schools. Professor Huxley, in his essay on Technical Education, says: "The educational abomination of desolation of the present day is the stimulation of young people to work at high pressure by incessant competitive examinations."

707. There is a large increase in the number of suicides in the general community, and there is good reason for attributing this in great part to the fact that the struggle for life and the keenness of competition are too severe, and that there has been undue pressure and strain on the brain and nervous system in the fast age in which we live.

CHAPTER XXII.

FIRST TREATMENT OF ACCIDENTS AND EMERGENCIES: FAINTING—SUFFOCATION—DROWNING—HANGING—CHOKING—INJURIOUS GASES—SUNSTROKE—TEMPORARY SPLINTS—ARREST OF BLEEDING—BURNS AND SCALDS—FROST-BITE—BITES OF ANIMALS—CINDERS, ETC., IN THE EYE—FALLS AND BLOWS—SHOCK—FIRE-ESCAPES—FIRE-DRILL.

708. **Accidents of a more or less serious** nature are of frequent occurrence, and in the absence of a medical practitioner, non-professional persons may be called upon to furnish relief. A consideration of the most common accidents, and a few plain rules which may enable one to act in cases of sudden illness or injury until a physician arrives, will, therefore, be opportune in a work on Hygiene.

709. **Fainting, or syncope**, is due to a temporary diminution or suspension of the action of the heart, and is accompanied by interruption of the breathing and temporary insensibility. Fainting may occur suddenly; usually, however, the patient has some premonition, such as a feeling of sickness or uneasiness in the stomach, or swimming in the head, or mental confusion, while the bystanders observe its approach in the remarkable change of color in the countenance, which becomes ghastly pale. When the patient has passed into a complete state of swoon, the surface of the body is cool and clammy; the pulse, at first, very feeble, or entirely gone; the heart's sounds hardly recognisable when the ear is placed on the chest; he lies insensible to all about him. This condition continues for a longer or shorter time, usually not more than a few seconds or minutes, and then the anxiety of the onlookers is relieved by the patient drawing a breath. Consciousness speedily returns, and with it color to the blanched lips and face, and the power of muscular movement.

710. **The causes of attacks** of fainting are numerous and various: some of them operate on the heart itself, and others through the medium of the nervous system. Among the most common in their

occurrence are diseases or injuries causing great pain: a blow on the stomach will also produce fainting. Again, everyone is familiar with the fact that fainting is caused by violent shocks, such as are produced by intelligence of a joyful or mournful nature being suddenly communicated, or from witnessing sights of a distressing or revolting character. Other influences have a similar effect; for example, a heated atmosphere or a crowded apartment, and certain overpowering odors, more especially those which produce a feeling of nausea or sickness. A draught of cold water taken when the body is hot often exerts a most depressing influence, and may produce syncope. Loss of blood is a frequent cause of fainting, sometimes to a fatal degree. When fainting occurs in connection with certain diseases—as, for example, disease of the heart—it is to be regarded as of a very dangerous nature, and not unfrequently, under such circumstances, death ensues. When, on the other hand, the attack of fainting occurs in persons who are free from any organic disease, and as the result of the operation of one or other of the causes of syncope already mentioned, recovery speedily takes place. There are certain persons, chiefly females, who are peculiarly liable to faint.

711. The treatment consists in placing the patient in the horizontal posture, the head being on the same level as the body and extremities; the access of fresh and cool air should be secured, and all tight articles of dress removed. The ordinary smelling salts, or strong vinegar, should be held near the nose, and a little cold water dashed over the face: these means seem to arouse the nervous system and renew the supply of blood to the brain. When the patient is able to swallow, some warm brandy and water should be administered, or wine and water, or a little sal volatile. In instances of protracted duration, external remedies may be employed, such as the application of mustard poultices to the extremities; while, till the power of swallowing returns, warm injections of brandy and water may be used.

712. Suffocation means death or suspended animation resulting from impeded respiration, as by the inhalation of noxious gases, or by drowning, strangulation or smothering.

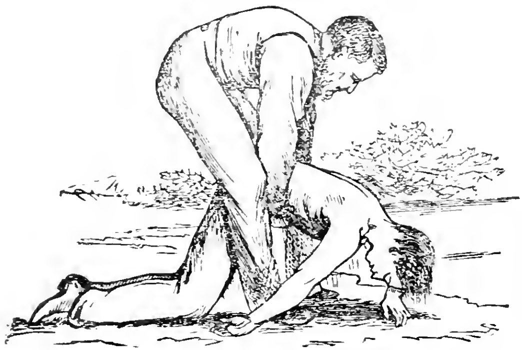
713. To prevent death from drowning and other modes of suffocation, placards containing the following directions have been issued by the Provincial Board of Health. Every school should have copies

conspicuously posted. Municipal authorities should take the same action. The information may also be circulated in pamphlet form :—

714. "**Treatment of the drowned.**—Read this paper *now*, so as to be ready to act in an emergency. Keep it for reference, and post it in a conspicuous place.

"Rule 1. Proceed *at once* to employ means to restore breathing. Do not delay this in order to procure shelter, warmth, stimulants, etc.

"Rule 2. *Remove all obstructions to breathing.*—Instantly loosen or cut apart all neck and waist bands; turn the patient on his face, with the head lower than the feet; stand astride the hips [Fig. 83], with your face towards his head, and, locking your fingers together under his belly, raise the body as high as you can without lifting the forehead off the ground, and give the body a smart jerk, to remove mucus and water from the mouth and windpipe. Hold the body suspended long enough to slowly count one, two, three, four, five, repeating the jerk more gently two or three times.



[Fig. 83.—First position of the drowned: to remove water and mucus from the throat and windpipe.]

"Rule 3. Next place the patient on his back on a flat surface, inclined a little from the feet upwards, raise and support the head and shoulders on a firm cushion or folded article of dress, placed under the shoulder blades. Cleanse the mouth and nostrils, open the mouth, draw forward the patient's tongue, securing it there either by holding it with the fingers, or by a piece of string or an elastic band placed over it and under the chin.

"Rule 4. Grasp the patient's arms just above the elbows, and draw them gently and steadily upwards until they meet above the head. (This is for the purpose of drawing air into the lungs.) [Fig. 84.]

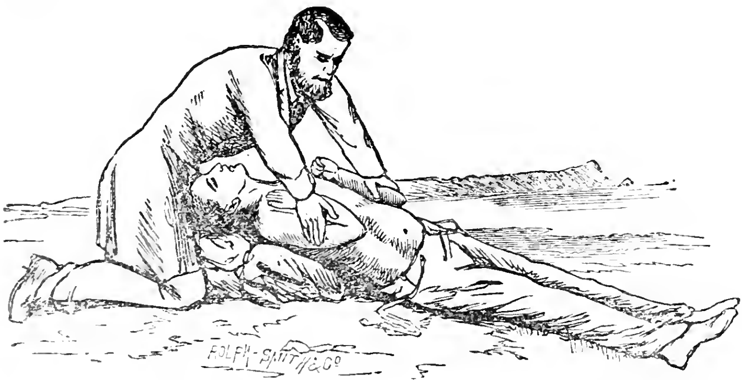
"Keep the arms in this position for two seconds, then turn them down and press them gently and firmly for two seconds against the sides

of the chest, pressing at the same time on the breast and abdomen. (This is with the object of pressing air out of the lungs.) [Fig. 85.]

[Fig. 84.—Second position: for the purpose of drawing air into the lungs.]

"Pressure on the breast-bone and abdomen by an assistant will aid this action.

"Repeat these measures alternately and deliberately until a spontaneous effort to breathe is perceived, immediately upon which cease



[Fig. 85.—Third position: for the purpose of expelling air from the lungs.]

to imitate the movements of breathing, and proceed to induce circulation and warmth.

"Rule 5. *To excite respiration.*—During the employment of the above methods excite the nostrils with snuff or smelling-salts, or tickle the throat with a feather. Rub the chest and face briskly, and dash cold and hot water alternately upon the patient.

"Do not be too soon discouraged. Remember that at any time within two hours your efforts may be successful.

"Rule 6. *To induce circulation and warmth.*—After breathing is commenced wrap the patient in warm blankets, and apply bottles of hot water, hot bricks, or anything to restore heat.

"Warm the head nearly as fast as the body, lest convulsions should be induced. Rubbing the body with warm cloths, or with the hands, and slapping the fleshy parts, may assist to restore warmth and breathing.

"If the patient can swallow *with safety*, give him hot coffee, tea, milk, or spirits. Allow the patient to have abundance of fresh air.

"*Hints to wharf owners, and to other persons residing near the water.*—Keep a coil of rope and pieces of boards in some convenient place, ready for immediate use.

"*To persons who cannot swim.*—If you get into water beyond your depth, do not plunge, struggle, nor throw your hands and arms out of the water. 'Tread water' in the erect position, by moving the feet up and down, at the same time slowly paddling with the hands, keeping them under water. If any person approaches to rescue you, preserve your presence of mind and do not grasp him; do what he tells you. If any small object of support be thrown to you, place it under your chest or arm-pits, and do not struggle to raise yourself out of the water; your head will not go under if you follow these directions; and you may keep your mouth and nose above water long enough for assistance to arrive. By considering these directions carefully *now*, you will be less apt to lose your presence of mind should occasion arise for acting on them.

"Parents should have their children taught to swim. Many deaths might be thereby averted.

N.B.—In *suffocation by smoke or any poisonous gas*, as also in cases of *hanging or choking*, proceed in the same way as in drowning, seeing that no obstruction exists in the mouth and throat, but omitting the efforts to expel water, etc., from the lungs."

715. When a person is found hanging by the neck, the first thing to be done is to remove all constrictions from the neck. The finger should then be pushed to the back of the tongue, and any mucus which may be found there removed from the mouth. Cold water should be dashed on the head and neck. If these means prove unsuccessful, artificial respiration should be tried.

716. Choking occasionally endangers life, owing to the presence of foreign bodies in the gullet, causing pressure on the windpipe. In such circumstances, the efforts of the sufferer to swallow may cause the passage of the obstructing substance downwards into the stomach. If this should not occur, assistance is required. The treatment consists in holding the head low and slapping the back. One or two fingers should then be put into the throat and efforts made to dislodge the substance; or one hand should be placed on each side of the chest, suddenly compressing it, and thus producing a blowing out of the air. This latter expedient is more particularly useful in cases in which the offending substance has been drawn into the orifice of the windpipe, which lies just behind the root of the tongue, and in front of the gullet. When the patient is choked by a piece of food, and we are sure, upon examination, that it has passed below the opening into the windpipe, it may be disposed of, if suffocation still continues, by rapidly introducing into the gullet a long piece of whalebone, or other smooth, flexible substance, the end of which is protected by a piece of sponge or cotton batting, and pushing the morsel down towards the stomach. When the impacted body is of an unyielding nature, as, for instance, a piece of money, harm may be done by unskilled manipulation.

717. Infants and aged and intoxicated persons are sometimes accidentally suffocated by falling, so that the mouth and nose are buried in mud, water, dust or other substances; under such circumstances death may speedily take place. Persons are frequently suffocated in large masses of grain. Accidental suffocation is not uncommon among infants when they sleep with adult persons. Even the close wrapping up of a child's head in a shawl to protect it from cold may cause its death, without any struggles to indicate the danger to which it is exposed. The treatment in such cases is the same as that described in Secs. 713–716.

718. The symptoms of poisoning by carbon dioxide vary, according to the quantity of air which is breathed. In a concentrated state there is sudden insensibility, followed by death unless the person is immediately removed into the pure air.

719. Precautions must be taken before entering a place where this gas exists, more particularly if it be in a confined spot, as in a well or cellar, vat, etc. Lime thrown into such places soon absorbs the gas; or it may, in certain cases, be got rid of by the agency of ascensional currents of air, caused by combustion, or, what is better when available, a jet of steam. Lives are often successively lost on these occasions in consequence of persons descending one after another, in the vain expectation of at least being able to attach a rope to the body of the insensible person. The moment that the mouth comes within the level of the invisible stratum of gas muscular power is lost, and the person commonly sinks lifeless.

720. The burning of a candle is commonly said to be a criterion of safety against the effects of carbon dioxide. It is true that in gaseous mixtures where a candle is extinguished it would not be safe to venture, but the converse of this proposition is not true, namely—that a mixture in which a candle burns may be always respired with safety. It has been observed on several occasions, that the combustion of charcoal has been maintained in a room in which persons have been found in a state of insensibility from breathing the vapor.

721. Carbon monoxide, which arises from the smothered combustion of coal, wood, or charcoal, acts like a pure narcotic poison. Persons breathing it in a concentrated form become rapidly insensible. The action of this vapor is very insidious; one of its first effects is the utter prostration of strength, so that, even on a person awake and active, the gas may speedily produce a perfect inability to move or to call for assistance.

722. The deleterious effects arising from breathing confined air, coal-gas, hydrogen-sulphide, and vapors arising from lime-kilns, brick-fields and cement works, have already been mentioned. (Secs. 51–57.)

723. Sunstroke, or heat-stroke, is likely to result from working in a heated atmosphere, either with or without exposure to the sun's rays. Most cases are preceded by headache, sense of weakness at the pit of the stomach, weakness of the knees, and sometimes vomiting

and distorted vision. Insensibility follows these symptoms or may occur suddenly The head is hot, and the face is red, or even purple. The breathing is slow and labored; the pulse full, but weak. The treatment consists in placing the patient in a cool place and applying cold water, or pounded ice in cloths, to the head, back of the neck and spine. In a certain number of instances the symptoms are more those of exhaustion. The face is not as much flushed, and may even be pale. The pulse is frequent and feeble, and there is no difficulty in breathing. In these cases stimulants should be given gradually and the cold applications should be used sparingly.

724. Poisons are substances which, when taken into the blood, are capable of destroying life. They are divided into classes, according to their action on the body. (1), *Irritants* destroy the tissues and produce nervous shock; (2), *narcotics* produce insensibility by their action on the brain; (3), *narcotico-irritants* combine the action of narcotics and irritants.

725. The general treatment in poisoning consists (1), in removing the poison from the stomach; (2), in counteracting its effects by antidotes, which will mechanically or chemically render it harmless; (3), in remedying the effects produced, and obviating the tendency to death: stimulants, artificial respiration and exciting the excretory organs are some of the means used for these purposes.

726. Emetics are used for the purpose of causing vomiting. The safest and readiest are irritating the back of the throat with the finger or a feather, large draughts of tepid water, combined with a tablespoonful of salt or mustard, or one or two tablespoonfuls of wine of ipecacuanha in water.

727. Acids and alkalies form antidotes to each other. The acids suitable for the purpose are vinegar, and the juice of the lemon or the orange, mixed with water. The alkalies are soda, potash, lime and magnesia, diluted with water.

728. Albumen and oils will protect the gullet and walls of the stomach in poisoning by irritants. White of egg, milk, flour and water, and castor oil may be used

729. The following are the more common poisons and antidotes; some antidotes which cannot with safety be employed except by medi-

cal men, are omitted; in all cases medical aid should be secured as quickly as possible:—

Poisons.	Antidotes.
Arsenic (rat poison, Scheele's Green, Paris Green)	Emetics; milk; peroxide of iron; white of eggs; magnesia; oils and fats.
Antimony (butter of antimony and tartar emetic)	Encourage vomiting; milk; tea; tannin, or other vegetable astringents.
Mineral acids (oil of vitriol, aqua-fortis, spirit of salt)	Encourage vomiting; alkalies; wall plaster; afterwards give flaxseed tea or other demulcent drinks.
Oxalic acid	Emetics; lime water; chalk; magnesia; whiting.
Carbolic acid	Lime water; sweet oil; stimulants.
Alkalies (caustic potash, soda or lime)	Acids; vinegar and water; juice of the lemon or orange in water; emetics; salad oil.
Phosphorus (rat poison, matches)	Encourage vomiting by large draughts of tepid water; large doses of magnesia in water; avoid oils.
Salts of mercury (calomel, corrosive sublimate)	Encourage vomiting; white of eggs; flour and water; milk.
Salts of lead (sugar of lead, paint)	Emetics and Epsom salts.
Nitrate of silver	Common salt and water.
Irritant gases and chloroform	Fresh air; loosen the dress; artificial respiration; dash cold water about the face and neck. For chloroform also lower the head and raise the lower parts of the body.
Prussic acid (cyanide of potassium)	Cold douche; sal volatile to the nostrils; artificial respiration; brandy and ammonia.
Strychnia (nux vomica)	Emetics; cold affusion; artificial respiration; brandy and ammonia.
Narcotics (opium, morphine, laudanum, paregoric)	Emetics; strong coffee; cold affusion; forced walking about.
Alcohol (brandy, whiskey, etc.)	Emetics; cold affusion; warmth to the surface of the body; a teaspoonful of vinegar in water.

730. Iodide of starch is an efficacious antidote in poisoning by

hydrogen sulphide, the alkalies, the alkaline sulphides, and especially the alkaloids, with which iodine forms an insoluble compound.

731. Another "multiple antidote" is given, as follows:—Saturated solution of sulphate of iron, 100 parts; water, 800 parts; calcined magnesia, 88 parts; purified animal charcoal, 40 parts. The iron solution should be kept separately, and the magnesia and charcoal mixed in a bottle, and the whole well shaken together. It may be administered *ad libitum*, a wineglassful or more at a time. It is said to render preparations of zinc, arsenic and digitalis absolutely inert, and to partly neutralize the action of mercury, morphia and strychnine. It has, however, no action on the alkaloids, phosphorus or prussic acid.

732. Dislocations consist in the removal of bones from their natural position in the joints. The joints most subject to dislocation are those of the extremities.

733. Fracture consists in the breaking of a bone. It may be simple, in which case the bone only is divided; or compound, when the tissues or integuments covering the fractured bone are also lacerated, making a communication between the bone and the external air. In dislocation, the restoration of the bone to its proper position is sometimes a matter of ease, but in other instances it is attended with no small difficulty. The sooner attempts at reduction are made after the accident which has caused the dislocation, the better, they are then more certain to be followed by success. The same observation applies to the case of fractures; the setting of these is best effected as soon as possible after the reception of the injury.

734. For the treatment of both injuries experience and skill are required. It is of great importance, till suitable assistance can be obtained, that the injured parts be placed in a position at once the most comfortable to the sufferer, and in which a further injury is least apt to occur. The recumbent posture should, as a general rule, be maintained; and in fractures all motion of the broken bone should be prevented by the application of splints, retained by a firm bandage. If the fracture is a compound one, and bleeding to any extent has occurred, a handkerchief should be tied very tightly around the limb above the seat of fracture, and a pledget of lint or of cotton cloth wrung out of cold water applied over it.

735. **Splints** are appliances used in treating fractures, for supporting the bones in their natural position till a cure is effected. The materials chiefly used for making splints are wood, iron, pasteboard, leather, gutta-percha, felt, wire, tin and bark. Extemporized splints may be formed with umbrellas, walking-sticks, cigar boxes, folded newspapers, policemen's truncheons, and soldiers' weapons, such as rifles, swords or bayonets. Splints should be well padded with wool, cotton wool, tow, flannel or lint. Bandages are usually made from unbleached calico, flannel, linen, webbing, etc.

736. **Roller bandages.** the kind in ordinary use, may be made in certain convenient sizes, according to the part of the body for which they are required, as follows :—

For the fingers	......	$\frac{3}{4}$ inch wide, 1 yard long.
" arm	.. ..	$2\frac{1}{2}$ inches wide, and 3 to 6 yards long.
" leg	....	3 inches wide, and 6 to 8 yards long.
" chest	....	4 to 5 inches wide, and 8 to 12 yards long.
" head	....	$2\frac{1}{2}$ inches wide, and 4 to 6 yards long.

737. **In applying a roller bandage.** (1) begin from below, and work upwards; (2) insure that the pressure is uniformly and evenly applied; (3) avoid wrinkles; (4) bandage from within outwards; (5) where the limb is of uniform thickness use the simple spiral, where the limb thickens reverse the spiral, and at joints use the figure of eight; (6) reverse the bandage on the fleshy side of the limb, and not over the sharp edges of the bone. The application of bandages is best learned by practical lessons.

738. **Hæmorrhage, or bleeding.** is the result of the opening of a blood-vessel by a wound or otherwise. It may be external or internal. Hæmorrhage it divided into (1) *arterial*, where the blood flows in jets, in great force, and is of a bright red color; (2) *venous*, where it flows slowly—wells out—and is of a dark purple color; (3) *capillary*, where there is a general oozing from the surface.

739. **The treatment** in arterial hæmorrhage consists in (1) exposing and examining the wound; (2) washing it with cold or hot water; (3) elevating the bleeding part, while the body is allowed to remain in a recumbent posture; (4) applying pressure with the fingers directly over the mouths of the bleeding vessels; (5) applying pressure to the main artery on the heart side with the fingers, or with a pad and

bandage (Fig. 86)—this bandage may be tightened by twisting it by means of a piece of wood inserted in it; (6) applying a pad and bandage over the wound as an additional safeguard.

740. Venous hæmorrhage may occur with arterial or by itself. A superficial wound is more likely to divide veins than arteries. Dangerous venous bleeding often takes place when the patient has varicose veins and ulcers on the lower limbs. The direction of the flow of blood towards the heart, just the reverse of what obtains in the arteries, is a fact which bears on the treatment. This consists in (1) examining and exposing the wound; (2) washing it well with cold or hot water; (3) elevating the limb, keeping the body in a recumbent posture; (4) applying a pad and bandage over the wound; (5) removing any pressure or restriction to the circulation on the heart side, such as tight clothing—this cannot be done where arterial bleeding has also to be treated.

Fig. 86.—Arrest of circulation in the leg by means of a twisted bandage.

741. Capillary hæmorrhage is easily controlled: (1) by applying direct pressure to the bleeding surface; (2) application of ice or of styptics, such as alum, tincture of iron, caustic, etc.

742. Internal hæmorrhage, except in cases such as the bursting of an aneurism, is seldom so rapid as not to give time for skilled aid. The treatment consists in (1) placing the patient in the recumbent posture; (2) applying ice to, or as near as possible to, the part affected; (3) sucking ice is useful in bleeding about the mouth, throat, air-passages, or stomach.

743. Bleeding from the nose is the most frequent of all hæmorrhages, while it is only in occasional cases that it requires special treatment. In those who are constitutionally predisposed to it, slight causes suffice to provoke its occurrence, such as blows upon the nose, sudden and violent sneezing, coughing, laughter, any very powerful muscular exertion, exposure to great heat of the sun or from fires; interrupted

return of blood from the head, as by wearing tight neck bands; irritation of the nostrils by picking; any causes which may tend to produce a flow of blood to the head or face, as in taking drinks or food, hence those who are subject to this complaint suffer generally after dinner. Bleeding from the nose is found to occur in cases of polypus, and in connection with inflammatory action and ulceration within the nostrils. Among the morbid constitutional conditions in which nasal bleeding is prone to occur, may be mentioned that one,—common in children,—in which there exists a general tendency to hæmorrhage, due to a particular condition of the blood, while the bleeding is not from the nose alone, but from the nose and mouth, as well as other mucous surfaces. As a complication, and at times a severe one, nasal bleeding is found occurring in the course of fevers and inflammatory disorders. In certain structural diseases of organs, this form of hæmorrhage is apt to occur, as in those of the liver, lungs and heart, but chiefly the kidneys.

744. The ordinary means for arresting bleeding from the nostrils are: pressing of the nostrils together, and the application of cold water to the forehead and nose; also the sudden application of any very cold substance to the surface of the body, even at a distance, as, for example, of a key to the back, by which a sympathetic contraction of the superficial blood-vessels is occasioned. Effectual pressure may be made by the thumb and finger pinching and pressing backwards on the nose just below its bony portion, or pressure may be exerted over the upper lip; in either case a small blood-vessel going to the nostrils is compressed. Meantime the patient should be placed in a chair or on a bed, with the head kept up and bent a little backwards, the necktie or any tight article of dress being removed.

745. Should these means prove unsuccessful, recourse must be had to astringent remedies. A solution of alum, in the proportion of 15 or 20 grains to the ounce of water, should be applied freely to the interior of the nostrils. Small pieces of lint, soaked in strong infusions of kino or rhattany, may be inserted into the bleeding nostril or nostrils, or the infusions may be injected by means of a syringe. In addition to these local means, M. Negrier, of Angers, has called attention to a plan which he has frequently employed, and invariably with success. It consists in causing the sufferer, while maintaining

the erect position, suddenly to raise both arms perpendicularly upward, and to retain them for a short time in that position. If only one arm is raised, it should be that of the side upon which the bleeding occurs, and then with the other hand the patient may compress the bleeding nostril. In cases of young children, an attendant may perform both offices.

746. **A burn** is caused by intense, concentrated heat applied directly to the surface, or by chemical agents destroying the skin and the tissues underneath. A scald is produced by very hot liquid touching the skin; the cuticle is raised and destroyed, and the true skin reddened and inflamed. Besides their local action, burns and scalds are apt to produce dangerous effects by congestion of internal organs. The treatment of burns consists in the application of linseed oil and lime water (equal parts), olive oil, castor oil, or castor oil and collodion; the part should be then wrapped up in wool, cotton-wool or flannel. The readiest treatment for scalds consists in applying a strongly alkaline solution, made with carbonate of soda, baking soda, lime or magnesia. The scalded part should then be enclosed in cotton-wool, excluding air as far as possible.

747. **Frost-bite** is the result of exposure to severe cold. The vitality of the part is reduced to a very low point, it loses its natural color and becomes blue or purple. The treatment consists in bringing about re-action gradually. The patient should be placed in a room in which there is no fire. The affected part should be rubbed with snow or other cold application, and brandy and water should be carefully administered in small quantities. If a person is found insensible from cold, he must be kept away from the heat. His clothing should be removed, and he should be rubbed thoroughly with snow or cloths wrung out of cold water. The friction, especially to the extremities, should be continued until signs of recovery appear. Artificial respiration may be necessary. Brandy and hot milk, or beef tea, should be given.

748. **Absorption of poisonous material** from foul wounds and from poisoned wounds, often causes painful and serious inflammation of the lymphatic vessels and glands. (Fig. 87.) In the more simple forms the poisonous element is probably of a slightly irritating nature; it is generally some altered secretion of a simple wound, due to external

irritation. In the severe or more complicated forms, the poisonous element is of a more active kind, and has been introduced from without, as by a distinct animal poison, such as the bite of an animal for example, or by the irritation of some foul substance on the instrument which caused the wound, or it may be generated in a foul wound. In the treatment of such cases, the wound or sore should be thoroughly cleansed. The affected part should be raised higher than the rest of the body: if it be the foot, then it should be higher than the hip; the hand or elbow, higher than the shoulder. The treatment should be entrusted to a surgeon, as soon as the services of one can be obtained.

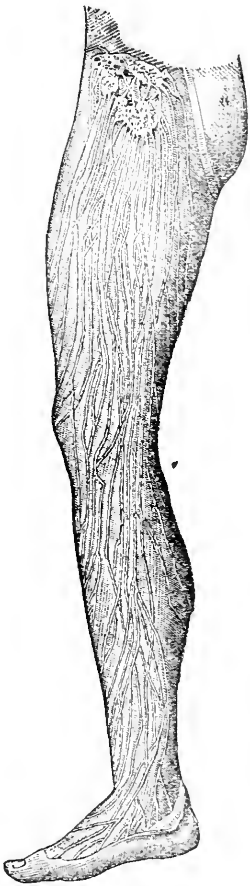


Fig. 87.—Lymphatic vessels and glands of the lower extremity.

749. Bites of rabid animals require immediate treatment. A ligature should, if possible, be applied on the side nearest the heart (see Fig. 86); the wound should be sucked, and then bathed with warm water, so as to encourage bleeding. It should then be burned with hot iron, nitrate of silver, or strong carbolic acid.

750. Foreign bodies in the eye cause considerable annoyance, and may be removed in the following manner: if the foreign body is under the upper eyelid, seat the patient in a chair, and standing behind, place a pencil or piece of stout wire on the central portion of the lid, lay hold of the eyelashes and erect the lid. Then having exposed the substance, brush it off with the corner of a handkerchief. If it is under the lower eyelid, simply depress this, and proceed as above with the handkerchief.

751. Concussion of the brain is caused by blows or falls upon the head. The characteristic symptoms are external bruises, etc., confusion of ideas, sickness and fainting. The patient lies pale and shiver-

ing; he is in a state of stupor or partial insensibility. The treatment consists in placing the patient on his back, with the head slightly raised, in a dark, quiet room; warmth should then be applied to the surface of the body and the extremities.

Blows on the abdomen have already been spoken of as one cause of fainting. It may be well to observe that ruptures of the liver, stomach, intestines, spleen and urinary bladder, occasionally result from violence directly applied to the abdomen. External marks or bruises on the abdomen are not always present in these cases: instances are on record where fatal results have followed blows on the abdomen, and no marks whatever of violence were discoverable on the external surface. In treating cases in which such injuries are supposed to have occurred, it is well, until professional assistance can be obtained, to place the patient in the horizontal position, in a state of complete repose. The circulation and respiration should be restored. All tightly fitting clothing should be removed from the neck, warmth may be applied to the surface of the body and extremities, stimulants in small quantities may be given.

752. Alarms of fire occurring in crowded buildings are often followed by distressing loss of life or severe bodily injury. People otherwise rational and methodical in their habits, become under the influence of panic a source of danger to their friends and associates, and are often quite unable to do themselves any real service. Great care and watchfulness are, therefore, necessary in the construction of public buildings, particularly schools, churches, theatres, etc., so that egress from them may be easily made. The doors leading from the auditorium to the main hall, and the outer doors, should be hinged so as to open outwards, and the passages leading to these doors should be spacious. Staircases should be made as straight as it is possible to have them, and their lower ends on the ground floor should always be made to open opposite a door leading to the outer air.

753. Permanent fire-escapes should also be provided by municipal by-law for all buildings over two stories in height. The terrible accidents and loss of life by fire which frequently occur in cities and towns, prove that efficient means of escape from a burning building are scarcely ever found when most wanted.

754. A cool, self-possessed deportment in the teacher, and the habit

of accustoming the scholars to fire-drill, will do much to rob a conflagration of many of its terrors. Smoke may also be occasionally used during drill, so as to make the scene more realistic. Obedience to the word of command should be prompt and unquestioning.

755. Children accustomed to fire-drill once a week are not likely in an emergency to give way to exhibitions of unbridled terror, but they will obey the commands of the teacher, and leave the room in an orderly fashion. Habits of this kind will be a valuable acquisition to the future men and women of the country, and may often be of service to them and their associates in after life.

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